



# Analysis of New Zealand's Trawl Grounds for Key Middle depths and Deepwater Tier 1 Fisheries

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J. Black  
R. Wood

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Publications Logistics Officer  
Ministry for Primary Industries  
PO Box 2526  
WELLINGTON 6140

Email: [brand@mpi.govt.nz](mailto:brand@mpi.govt.nz)

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## EXECUTIVE SUMMARY

**Black, J.; Wood, R. (2014). Analysis of New Zealand's Trawl Grounds for Key Middle depths and Deepwater Tier 1 Fisheries.**

*New Zealand Aquatic Environment and Biodiversity Report No. 122. 35 p.*

This report presents the results of an analysis of trawl catch effort processing return (TCEPR) data provided by the Ministry of Primary Industries for bottom trawling targeting the nine Tier 1 species (i.e., hake, hoki, jack mackerel, ling, orange roughy, oreo-dory, scampi, southern blue whiting, squid from the deepwater fish plan). The data and conclusions of this report are the same as those of Black and Wood (2010) but the text, tables and figures have been modified following discussions with the Aquatic Environment Working Group.

The input data for this analysis were all bottom trawl records, and those mid-water trawl records for which the ground rope depth equalled the bottom depth. The analysis estimates the total between-trawl-door swept area (i.e. the “trawl grounds”), resulting from bottom trawling targeted at Tier 1 species. The analysis was based on TCEPR reported to the Ministry by the fishing fleet. The swept area estimate is used to calculate statistics relating to the trawl grounds within the area inside the 200 nautical mile (M) line (i.e., in the Territorial Sea (TS) and the Exclusive Economic Zone (EEZ)). For the purposes of this report the two enclaves of international water, one on the Chatham Rise and the other on the Campbell Plateau, are included in the EEZ.

Statistics provided include the trawled area in the EEZ and TS and in relation to the National Aquatic Biodiversity Information System (NABIS) normal and full distribution ranges for each species and the Benthic-Optimised Marine Environment Classification (BOMECE) zones.

769 726 trawls targeting Tier 1 species during the 1989–90 to 2008–09 period were used for the calculations in this report. The number of trawls for each species ranges from 11 976 valid ling-targeted trawls to 318 944 valid hoki-targeted trawls. The number of trawls that occurred within the most recent fishing year (2008–09) ranges from 6 462 for hoki to 574 for southern blue whiting. For each species, the percentage of the respective NABIS range potentially affected by trawling is relatively low. The lowest percentage is for hake, for which the total swept area in the full and normal NABIS distribution ranges is 0.4% and 0.7% respectively. The highest percentage is for hoki; the total hoki-targeted swept area in the full and normal NABIS distribution ranges is 13.5% and 23.1% respectively.

The proportion of each BOMECE area that hasn't been trawled during the 1989–90 to 2008–09 period shows considerable variation, ranging from class 9 where only 28.3% has not been trawled, to class 15 where 99.9% has not been trawled. On average, 88.9% of the BOMECE cells have seen no trawling between 1989–90 and 2008–09, and 98.6% in 2008–09.

The results of this analysis are only estimates as uncertainties and errors in the input data make it impossible to make precise calculations. The estimates are likely to be minimums because the uncertainties associated with the input data tend to result in underestimates of the swept area for each tow, and some or all of the deleted trawls may be legitimate. It is likely that the uncertainty in the estimate of the total swept area is less than a few percent. Uncertainties in the knowledge of the true trawl paths mean that it is impossible to reliably infer the exact location and extent of trawls on the sea floor.

## 1. INTRODUCTION

The Deepwater Group Ltd requested GNS Science to analyse trawl catch effort processing return (TCEPR) data obtained from the Ministry of Primary Industries' (MPI) database to assess the extent of the bottom trawling grounds for the nine Tier 1 species (i.e., hake, hoki, jack mackerel, ling, orange roughy, oreo-dory, scampi, southern blue whiting, squid from the deepwater fish plan) in New Zealand's Exclusive Economic Zone (EEZ) and territorial sea (TS). The objective of this analysis was to determine the extent of the bottom-trawled grounds for Tier 1 species in relation to:

1. the total extent of the EEZ and TS
2. their known distribution ranges
3. various marine environment classification zones.

The data and conclusions of this report are the same as those of Black & Wood (2010) but the text, tables and figures have been modified following discussions with the Aquatic Environment Working Group. This analysis was undertaken as a first step towards assessing the potential impacts by the fishery on the benthic habitats of Tier 1 species and on the range of identified benthic habitat classifications.

The TCEPR data from the MPI database included 1 197 439 records. The input data for these analyses included all bottom trawl records and those mid-water trawl records for which the ground rope depth was equal to the bottom depth. The TCEPR records are known to contain errors. Editing removed tows that crossed land, zero-length tows and tows longer than 30 nautical miles (M). Approximately 13.5% of the records were deleted. This database was merged with one that contains trawl type information (single or twin rig).

Analysis of the area of sea floor swept by each trawl used estimates of between-trawl-door width for the trawl gear in each target fishery and the estimated distance swept by the trawl gear, based on start and end coordinates. This estimate assumes that the vessel location is a reasonable proxy for the net location, that the vessel travelled in a straight line between the start and end positions, and that the door-to-door width of the trawl was only a function of target species and trawl type. These assumptions reasonably reflect common fishing practices in the New Zealand deep water fishery.

Using these assumptions, the area of the trawl grounds for these species was estimated in relation to the area of the TS and EEZ and in relation to the area of the National Aquatic Biodiversity Information System (NABIS) normal (90%) and full (100%) distribution ranges, and the Benthic-Optimised Marine Environment Classification (BOMEC) zones. Other statistics provided include closed areas (benthic protection areas and 'Seamount' Closures) and large marine protected areas.

## 2. INPUT DATA AND EDITING

Only TCEPR data were used for this analysis. Catch effort landing return (CELR) and trawl catch effort return (TCER) data were not used because it was impossible to extract meaningful position information about individual trawls from those records. TCER data only

record start position, and CELR provide only the general area of fishing. The TCEPR data cover the period 1st October 1989 to 30th September 2009. Analysis of the four fishing years 2005/06 to 2008/09 shows that for the tier 1 species between 65% (ling) and 100% (southern blue whiting, scampi) of the catch come from tows recorded on TCEPR (Dave Foster, MPI pers. comm. 7 March 2012). For each of the remaining tier 1 species, the percentage of the catch recorded on TCEPR is 93% or greater, with the exception of jack mackerel at 78%.

The data were received from MPI as three separate datasets (6466, 7415 and 7770), covering the periods 1/10/1989 to 12/9/2006, 1/10/2005 to 30/9/2008, and 1/10/2008 to 30/09/2009. Duplicate records from the time overlap between the first two data sets were removed.

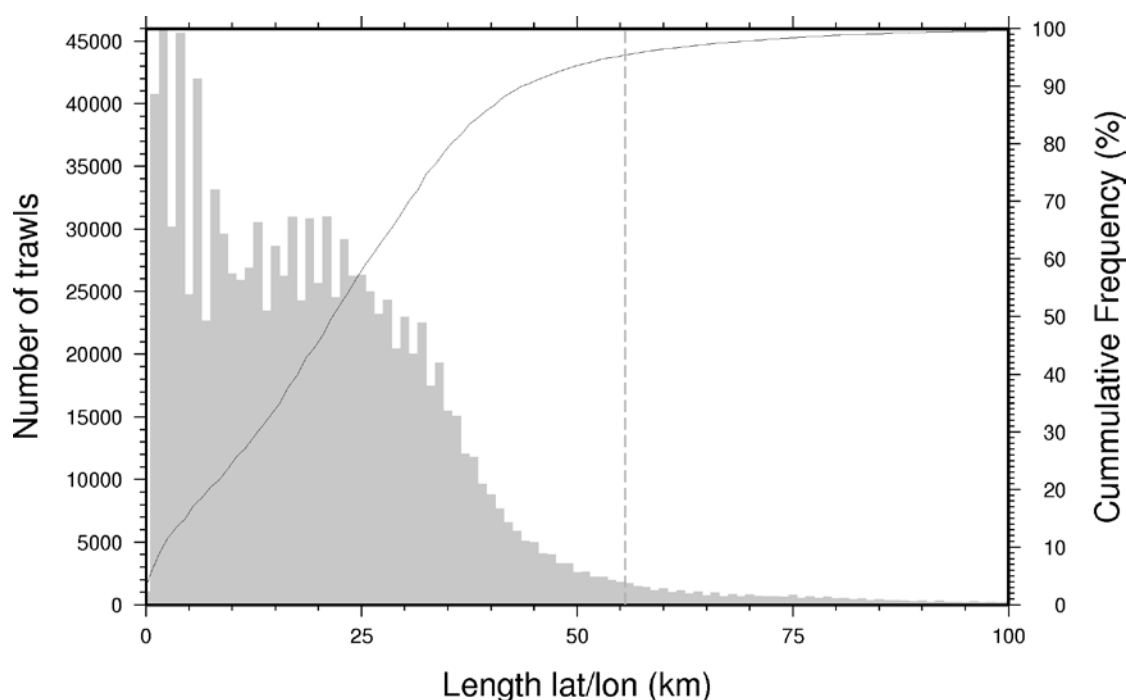
The original TCEPR data included records outside the EEZ (beyond the 200 M limit) that were not used in the analysis. Unlike in some previous studies, trawls inside the territorial sea were kept in the database. Editing of records in the EEZ and TS occurred both before and after the records were input as lines in ArcGIS 9.3, a geographic information system (GIS).

Before input into the GIS, editing involved flagging records with identical (43 848 records) or NULL start/end coordinates (350 records; **Table 1**). Records with identical start/end coordinates could be legitimate short tows, but their omission is unlikely to be important as they are relatively few in number and most lie inside the estimated trawl footprint area. If we were analysing fishing effort per unit area rather than the trawl footprint, it would be possible to include these tows in the analyses, but that was not the purpose of this study.

After the data were input into the GIS, editing involved (**Table 1**):

1. Flagging all records that cross land;
2. Flagging all tows greater than 30 M long (55.56 km).

Tows longer than 30 M (55 km) are not representative of common fishing practice in New Zealand and were considered to be errors. Many of the records with lengths greater than this have obvious errors in the start and/or end positions. About 95% of the distances calculated from the start and end positions are less than 30 M (Figure 1). The effect of not using tows between 30 M and 100 km (54 M) long is considered in section 4.1.4.



**Figure 1:** Distribution of trawl lengths in the TCEPR database, calculated from start and end positions. The solid line shows the cumulative percentage of trawls less than the trawl length along the X axis. The vertical dashed line is at 30 M (55.56 km).

**Table 1:** Results of editing of TCEPR input data. \* Total number of flagged records does not equal the sum of the above numbers as some records fall into multiple categories.

Edit Criterion	Records Flagged/Remaining
NULL longitude/latitude values	350
Same start/end location	43 848
Cross coastline	8 702
Outside EEZ	36 124
Long tows (> 30 M)	40 913
TOTAL flagged	123 467*
TOTAL remaining (all species)	1 073 972
TOTAL remaining (Tier 1 species)	769 726

Records that cross the boundary of the EEZ were kept in their entirety at this stage, and cropped to the boundary in a later step.

In total, 769 726 records were included in the calculations for Tier 1 species in this report.

Once the data were input into the GIS, they were linked with the trawl type database compiled by the National Institute of Water and Atmospheric Research (NIWA). In the TCEPR database all trawls by seven vessels known to have the capability to deploy a twin rig are marked as twin rig trawls. For each of those trawls, the NIWA database provides an estimate of the probability that the twin rig capability was actually used. The NIWA database divides the trawls into five types ( Table 2). This analysis assumed that all trawls of type 4 or 5 were twin rig trawls, and all remaining trawls were single rig.



**Table 2: Trawl type.**

Twin Trawl Code	Explanation
1	Single Trawl
2	Likely Single Trawl
3	Unknown
4	Likely Twin Trawl
5	Twin Trawl

The two databases were merged using the event key, a unique code for each trawl. There are a few instances where the event key for the same trawl is different in the two databases. These trawls were located and matched using the location, date and vessel ID of the trawls. The NIWA database has some trawls with no event key and these trawls were also matched to the TCEPR database using the location, date and vessel ID. The NIWA trawl type database covers the period Jan 1996 to April 2007. There are thought to have been no twin rig trawls before this period. For the period between April 2007 and September 2009, twin rig information is taken from MPI data on the number of nets used for each trawl.

The trawls for which a Tier 1 species was recorded as the target species were then extracted into separate databases, one for each species.

### **3. DATA ANALYSIS**

#### **3.1 Equal area projection**

The first step of data analysis was to project the data into an equal-area projection. This allows accurate computation of the areas throughout the region of interest. The details of the projection used are:

- Map Projection Name: Albers Conical Equal Area
  - Standard Parallel 1: -30.000000
  - Standard Parallel 2: -50.000000
  - Longitude of Central Meridian: 175.000000
  - Latitude of Projection Origin: -40.000000
  - False Easting: 0.000000
  - False Northing: 0.000000
- Planar Coordinate Information
  - Planar Distance Units: meters
  - Coordinate Encoding Method: coordinate pair
- Coordinate Representation
  - Abscissa Resolution: 0.001785
  - Ordinate Resolution: 0.001785
- Geodetic Model
  - Horizontal Datum Name: D\_WGS\_1984
  - Ellipsoid Name: WGS 1984
  - Semi-major Axis: 6378137.000000

– Denominator of Flattening Ratio: 298.257223

### 3.2 Estimation of total area

Using the projected trawl lines, the next step estimated the area covered by each trawl. The trawl width was assumed to be only a function of target species and trawl type (single or twin rig). Characteristic door-to-door widths of trawls for the Tier 1 species were provided by the Deepwater Group Ltd, based on industry experience. Each trawl was buffered in the GIS to the widths in Table 3. The assigned trawl widths are at the upper end of what is expected. This is to ensure the calculations do not introduce a systematic bias that underestimates the trawl footprint area as many of the other assumptions are also likely to result in underestimates of the footprint area (see section 4.1). 67 309 trawls were identified as probably using a twin-rig, based on the NIWA trawl type database mentioned in section 2.

**Table 3: Door-to-door widths assigned to GIS trawl lines.**

Target Species	Trawl Width (m)	
	Single	Double
LIN (Ling), SCI (Scampi)	70	140
BOE, SSO & OEO (Oreo), JMA (Jack Mackerel), ORH (Orange Roughy), SBW (Southern Blue Whiting), SQU (Squid)	150	300
HAK (Hake), HOK (Hoki)	200	400

For each target species, the individual buffered trawls were then merged. The ArcGIS software was used to create a merged polygon for the ling trawls and a second merged polygon for the southern blue whiting trawls. The ArcGIS software could not handle the entire data set of trawls for the larger fisheries, and specialised software was used to merge the trawl polygons for each of the remaining Tier 1 species.

The specialised software uses a GPC (General Polygon Clipper) algorithm, an algorithm for calculating the difference, intersection or union of arbitrary polygon sets developed by Alan Murta of the University of Manchester (<http://www.cs.man.ac.uk/~toby/gpc/>). It is memory efficient and handles large polygons well. Tests were carried out to ensure that the merged polygons exactly matched the outline of the original buffered tracks.

Once a merged polygon had been created for each target species, trawls that crossed the EEZ were cropped to the boundary. The outlines of benthic protection areas (BPAs), seamount closures and large marine reserves (Auckland and Kermadec Islands) were added to the GIS. The area calculations were then carried out.

The GIS used the total trawl grounds for each species to estimate the area and percentage of the EEZ and territorial sea that has been swept by bottom trawling targeting that species. The percentage of the EEZ and territorial sea that has either not been trawled or that is protected by seamount closures, BPAs or large marine reserves was calculated.

### 3.3 Species distribution ranges

The annual distribution range of each species was derived from the MPI National Aquatic Biodiversity Information System (NABIS) database of marine species distributions (Francis et al. 2003). The NABIS distribution maps show the geographic spread of each species and were generated using information derived from:

- TCEPRs for deepwater fishing vessels

- CELRs for inshore fishing vessels
- Scientific observer records
- Bottom trawl tows made by research vessels
- Literature sources.

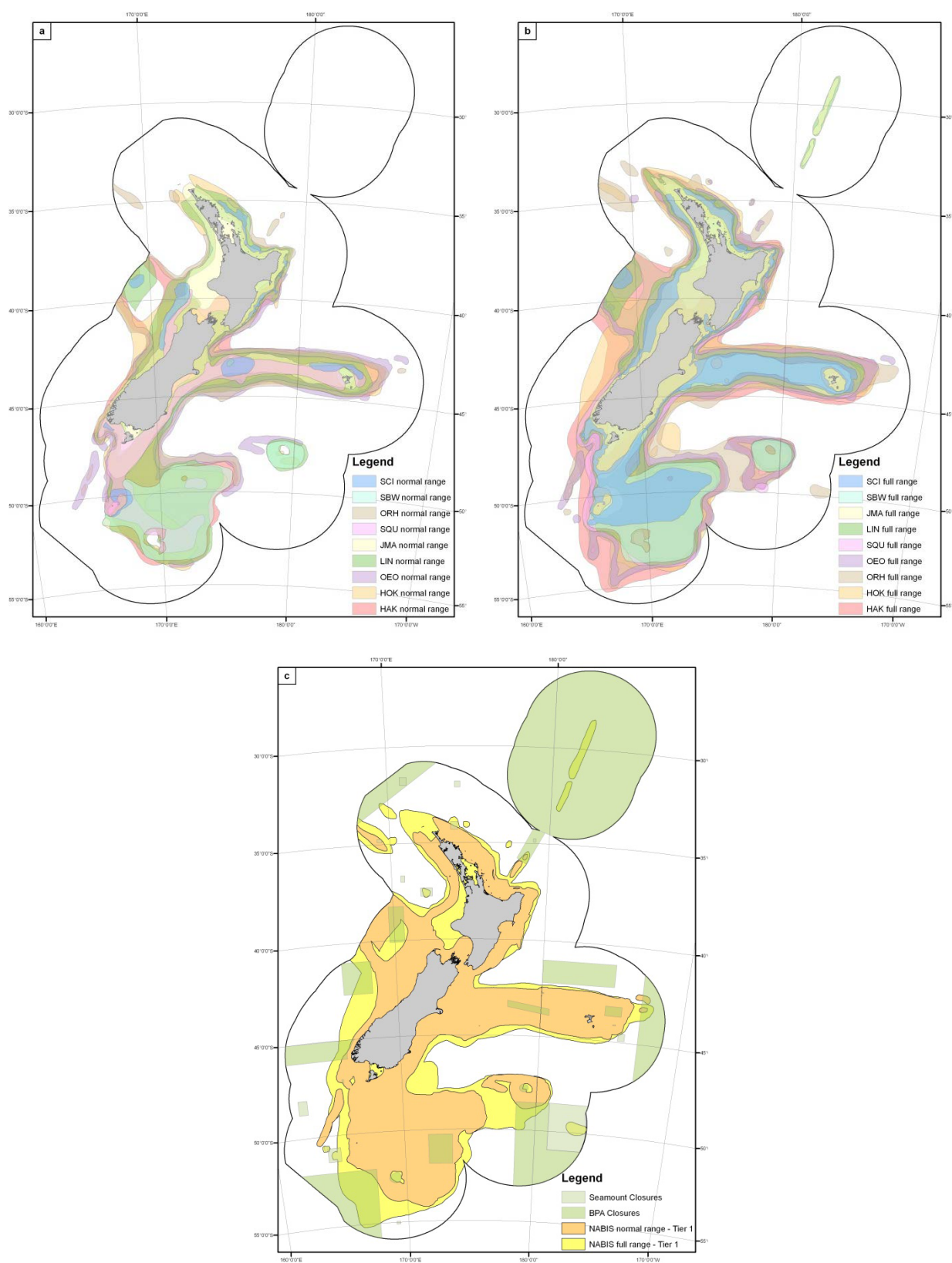
Statistics were calculated for the NABIS normal and full ranges for each species. The full range contains all known records of that species and the normal range the area in which 90% of the population is estimated to occur. Fish will not be evenly distributed within the NABIS range displayed.

The NABIS regions were provided as shapefiles, and were input directly into the GIS. They were clipped to the 200 M line and the coastline.

For the purposes of this analysis, black oreo (BOE) and smooth oreo (SSO) are considered together as oreo (OEO) because most records do not distinguish between them and report both as OEO. The NABIS ranges used for oreo are created by calculating the union of the BOE and SSO NABIS ranges.

Three jack mackerel species are harvested. NABIS distribution ranges are available for only two of these (horse mackerel and Murphy's mackerel). We have calculated the union of the two for use in this study.

We constructed NABIS normal and full distribution ranges to use for the combined data of all the Tier 1 species (Figure 2) by calculating the union of the 90% and 100% NABIS ranges for all of the Tier 1 species.



**Figure 2:** New Zealand's EEZ, showing (a) overlapping normal (90%) NABIS distribution ranges for each Tier 1 species, (b) overlapping full (100%) NABIS distribution ranges for each Tier 1 species, and (c) combined NABIS distribution ranges for the Tier 1 species, along with BPAs and 'Seamount' Closures. See Appendix 1 for figures showing the NABIS ranges separately for each of the Tier 1 species.

### **3.4 Fishing year**

Each trawl in the TCEPR database has the date recorded. This information is preserved in the analysis until the buffered trawls are merged to estimate the total trawl grounds. The fishing year runs from 1 October to 30 September the following year. All trawls in the most recent (2008–09) fishing year were extracted from the pre-merged databases for each of the Tier 1 species and merged in the GIS to estimate a total swept area for each species in the 2008–09 fishing year.

### **3.5 BOMECE classes**

Shapefiles of the boundaries of the Benthic-Optimised Marine Environment Classification (BOMECE) zones (Leathwick et al. 2010) were used. BOMECE was developed using generalised dissimilarity modelling to analyse a range of available environmental and biological data from the EEZ and TS, which enabled broad-scale spatial patterns to be identified in the marine ecosystem. These were weighted by the distributions of benthic fish species and invertebrates to provide a tool for managing the impacts of bottom trawling on benthic organisms and habitats (Leathwick et al. 2010). These shapefiles were added to the GIS, and trawl statistics calculated

## **4. RESULTS AND DISCUSSION**

### **4.1 Sources of uncertainty**

Several factors contribute to uncertainty in the estimated area of the total trawl grounds. These include:

1. The locations of start and end points are typically recorded to a precision of one nautical mile.
2. There is no information about the vessel path other than the start and end positions.
3. The locations are of the vessel, not the trawl gear.
4. Some of the deleted records are valid tows.
5. There could be undetected errors in the input data.

Consideration of these uncertainties indicates that the effect of each is likely to be no more than 1–1.5% of the area of the EEZ, as discussed below. When combined, these errors are likely to result in a small underestimate in the final statistics, which will be partly balanced by the overestimate in the trawl widths.

### **4.2 Start/end location precision**

Recording the start and end positions to a precision of one nautical mile means that trawls tend to cluster at certain points, and trawls can appear to overlies each other when they in fact have an effect on close, but different parts of the sea floor. The result of this imprecision is that the analysis of the trawl grounds is likely to underestimate the total area impacted.

Figure 3a illustrates the clustering of trawl end points. In this location trawls share a common end point, but because of their different headings the estimated areas for each trawl are nearly random and cover most of the sea floor. This pattern is the most common in the database except for short tows on small features.

To estimate the effect of clustered trawl end points, the start and end locations of 1 443 tows over a seabed feature were randomly varied by 1 km and the total trawl area estimated. The calculations were repeated 20 times. The original area estimation was 339 km<sup>2</sup>. The mean of

the estimates from the varied start and end locations was 344 km<sup>2</sup>, with a standard deviation of 4.6 km<sup>2</sup>. The results indicate that the imprecision in coordinates may result in an underestimate of the total area by about 1.5%.

#### **4.3 Trawl path**

The lack of information about the path the vessel takes between the start and end positions means that the path may be longer and therefore the analysis is likely to underestimate the area affected by each tow. In heavily fished areas the buffered tows typically overlap (Figure 3b) and the cumulative effect is likely to be small. This effect has not been estimated but it is likely to be no greater than the effect of start/end position precision.

Uncertainty in net location would be more important if the objective of this work was to predict the exact location of areas of seafloor affected by bottom trawling. It is likely to have little impact on the area calculations made here due to the overlapping nature of the trawls.

#### **4.4 Long tows and zero-length tows**

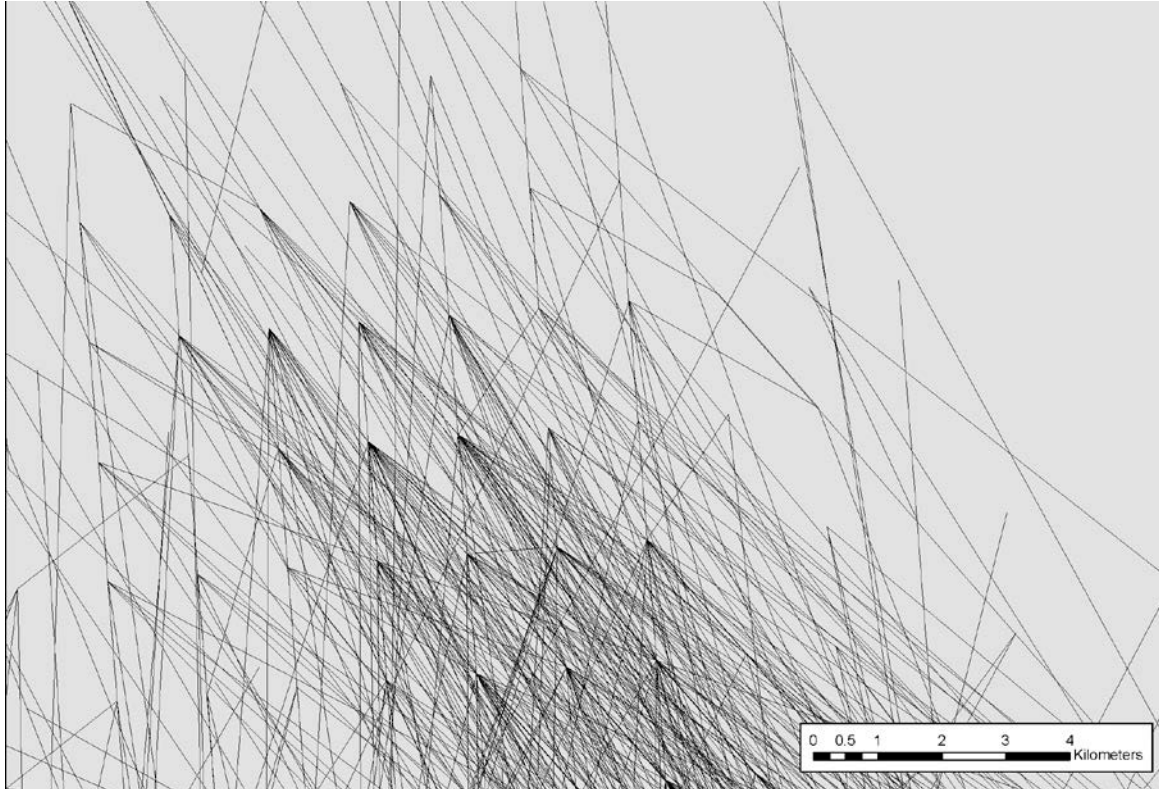
Tows with zero length (with NULL or identical start/end positions) and tows with lengths greater than 30 M are distributed throughout the fished area and account for the majority of deleted records (Table 1).

To evaluate the potential effect of deleting the long tows, records with lengths between 30 M and 100 km (54 M) were analysed and compared with the estimated trawl grounds. For simplicity, all the long tows were assumed to be 200 m wide, the maximum width for single-rig tows. Analysing the 1989–90 to 2007–08 dataset, the total area of seafloor affected by these long tows is estimated to be about 184 000 km<sup>2</sup>. However, about 75% of this area overlaps seafloor included in the estimated trawl grounds. If these long tows are valid then the area of additional seafloor affected by bottom trawling could be approximately 46,000 km<sup>2</sup>, about 2.7% of the area of the combined full NABIS range.

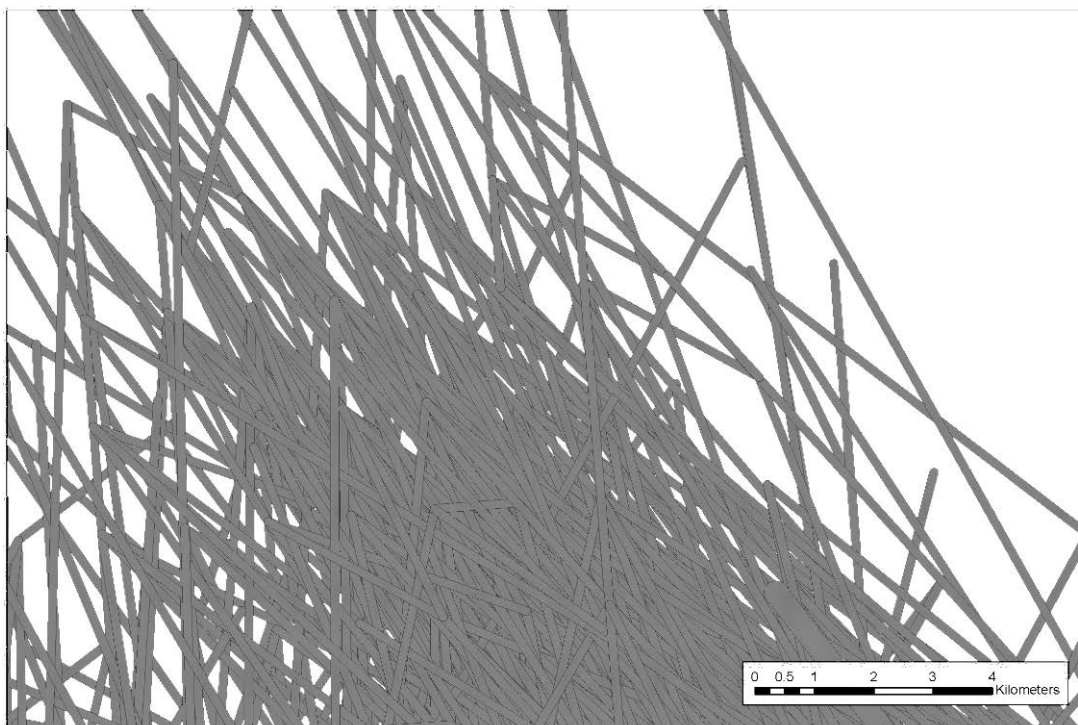
The tows with zero length could be either very short targeted tows or errors. 96% of them in the 1989–90 to 2007–08 dataset lie inside the estimated trawl grounds and it is unlikely that their exclusion has a significant effect on the final statistics.

#### **4.5 Undetected errors**

The editing undertaken for this project has identified the most obvious errors, commonly the result of typographic errors on the input forms. More subtle errors, such as small mistakes in position, would be impossible to detect. If these errors are either few or random, then they will have little effect on the final calculations.



**Figure 3a:** Typical pattern of trawls showing the effect of 1 nautical mile resolution in the start and end positions.



**Figure 3b:** Estimated trawl grounds area for the tow paths shown in Figure 3a.

#### 4.6 Target Species

In this analysis, target species is used as a proxy for fishery. The species caught as bycatch has not been considered.

This study uses the target species for each trawl, taken from the TCEPR 'effort' table, to estimate trawl widths because we considered it most likely that the trawl configuration would reflect the target species.

#### 4.7 Statistics

Trawl grounds statistics for each of the Tier 1 species for the full period (1989–90 to 2008–09) are given and illustrated in the appendices. Statistics calculated for the 2008–09 fishing year are also presented and illustrated in the appendices.

Hoki has by far the largest number of trawls over the 1989–90 to 2008–09 period (318 944) and the largest swept area for any of the individual Tier 1 species (165 195 km<sup>2</sup>). Squid has the second largest number of trawls (144 343).

Three of the analysed species have a similar number of trawls over the full time period: 13 447 hake-targeted trawls, 12 402 southern blue whiting-targeted trawls, and 11 976 ling-targeted trawls. The different spatial density of the trawls targeting each of these species leads to quite different total swept areas: 5 382 km<sup>2</sup> for hake, 17 627 km<sup>2</sup> for southern blue whiting and 12 627 km<sup>2</sup> for ling.

For each species, the percentage of the respective NABIS range potentially affected by trawling (over the full time period) is relatively low. The lowest is for hake and the highest is for hoki. The total hake-targeted swept area in the full and normal NABIS hake distribution ranges are 0.41% and 0.71% respectively. The total hoki-targeted swept area in the full and normal NABIS hoki distribution ranges are 13.49% and 23.12% respectively.

For the merged records of the nine Tier 1 species, 16.86% of the combined full NABIS range and 23.50% of the combined normal NABIS range has been swept,

The proportion of each BOMECE area that hasn't been trawled shows considerable variation, ranging from class 9 where only 28.3% has not been trawled, to class 15 where 99.9% has not been trawled. On average, 88.9% of the BOMECE cells have seen no trawling.

### 5. CONCLUSIONS

- TCEPR data can be used to estimate the trawl grounds for a specific species, and for a specific fishing year.
- The relationship between the number of trawls and the total swept area varies among the species. Three of the species have a similar number of trawls but their total swept areas vary by a factor of three.
- The percentage of the species-specific full NABIS range affected by trawling is relatively low – ranging from 0.41% for hake to 13.49% for hoki.
- The percentage of each BOMECE area that hasn't been trawled ranges from 28.3% for class 9 to 99.9% for class 15.



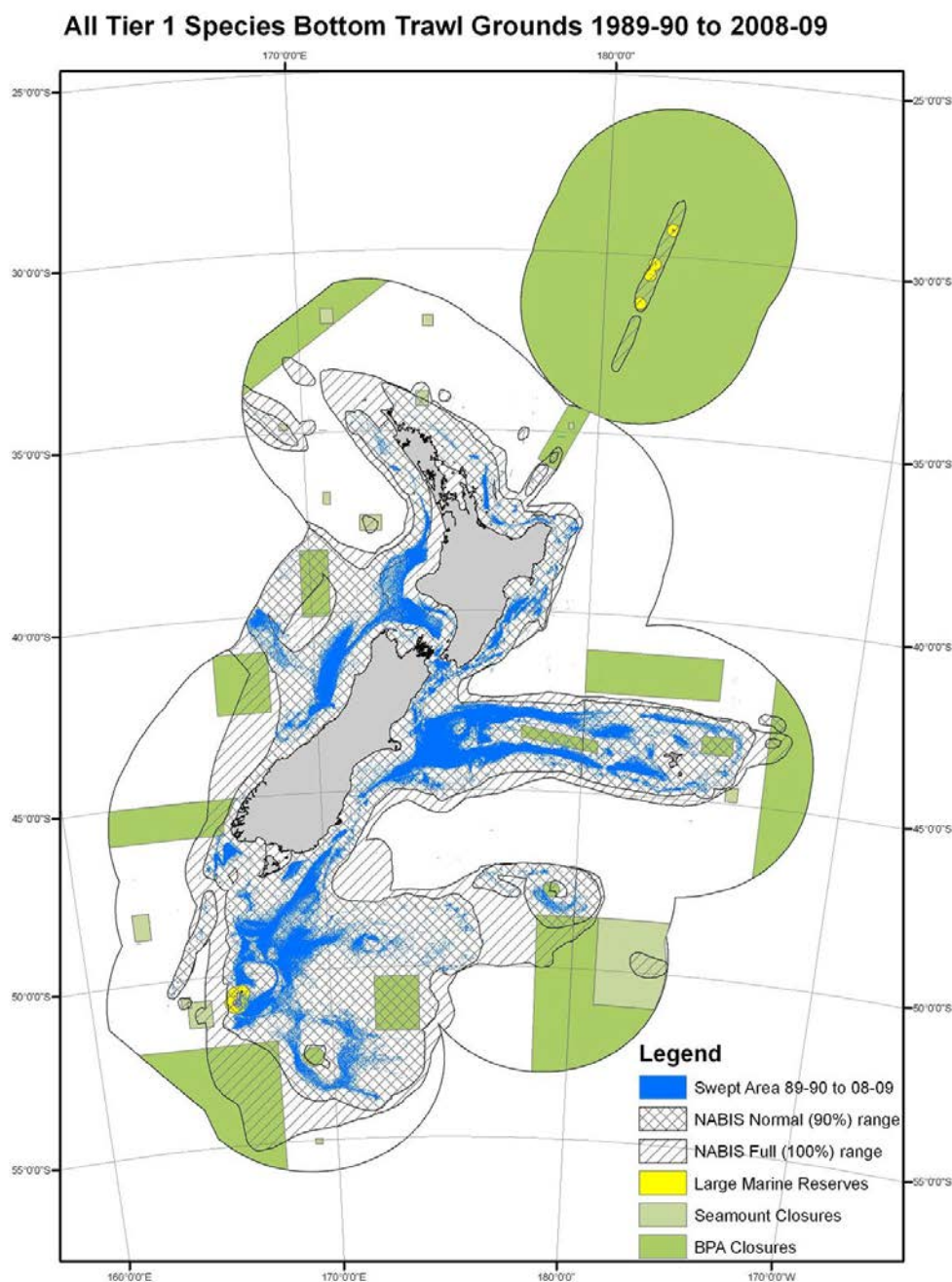
## **6. ACKNOWLEDGMENTS**

This work was originally funded by the Deepwater Group Ltd, and published as Black, J.; Wood, R. 2011. Analysis of New Zealand's Trawl Grounds for Key Middle Depths and Deepwater Tier 1 Fisheries, GNS Science Consultancy Report 2011/328 35p.

## **7. REFERENCES**

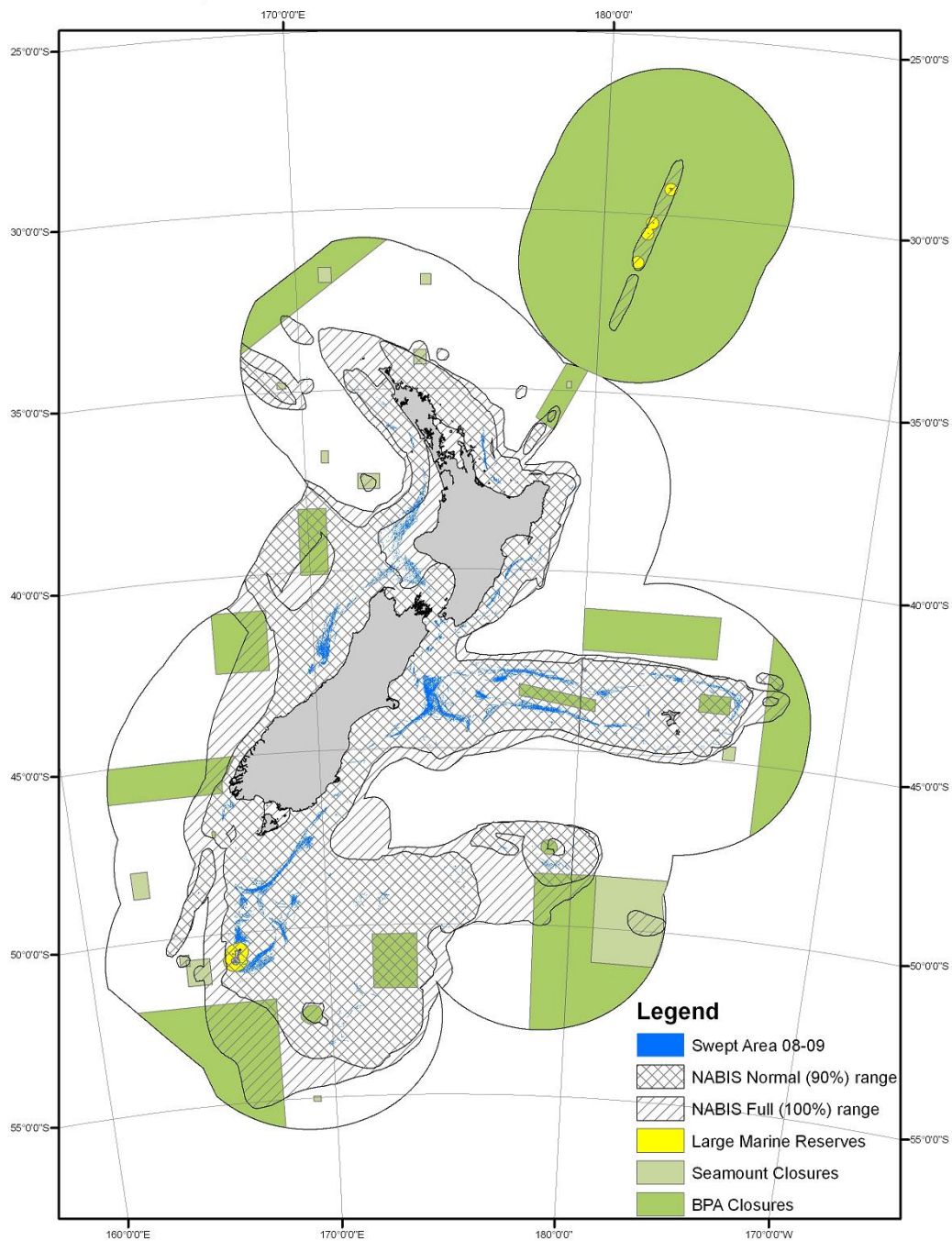
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## APPENDIX 1 TRAWL GROUNDS FIGURES AND STATISTICS



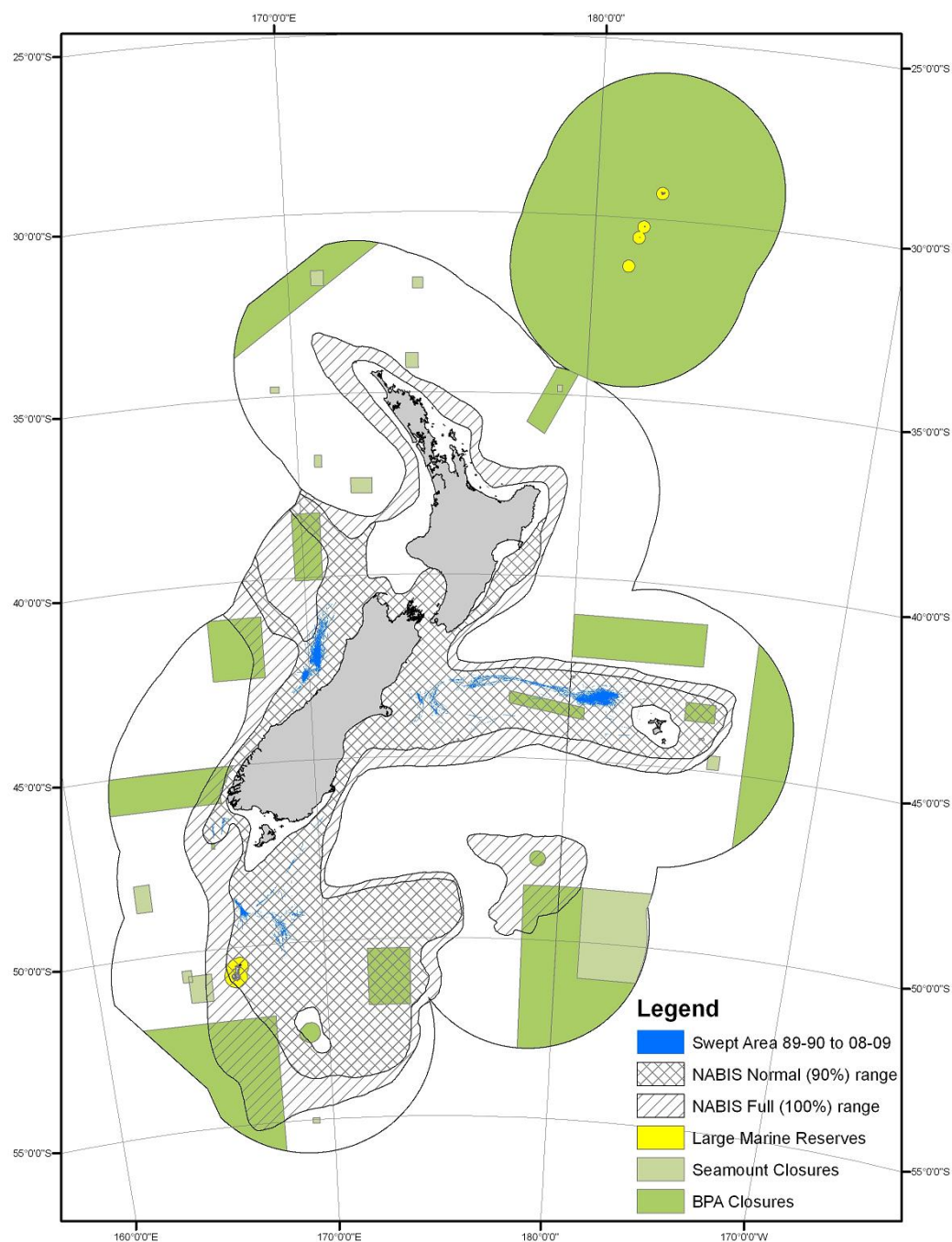
All Tier 1 Species Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 737 037	100.00%	1 175 749	100.00%
Swept Area	293 334	7.12%	292 857	16.86%	276 348	23.50%
Area not trawled	3 827 797	92.88%	1 444 180	83.14%	899 401	76.50%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	204 108	11.75%	65 797	5.60%
Closed and/or not trawled	3 829 027	92.91%	1 445 362	83.21%	900 519	76.59%
No. of bottom trawls	769 726		763 929		709 465	

## All Tier 1 Species Bottom Trawl Grounds 2008-09



All Tier 1 Species Bottom Trawl Grounds (2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 737 037	100.00%	1 175 749	100.00%
Swept Area	36 831	0.89%	36 814	2.12%	34 248	2.91%
Area not trawled	4 084 300	99.11%	1 700 223	97.88%	1 141 501	97.09%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	204 108	11.75%	65 797	5.60%
Closed and/or not trawled	4 084 341	99.11%	1 700 265	97.88%	1 141 543	97.09%
No. of bottom trawls	22 689		22 179		19 816	

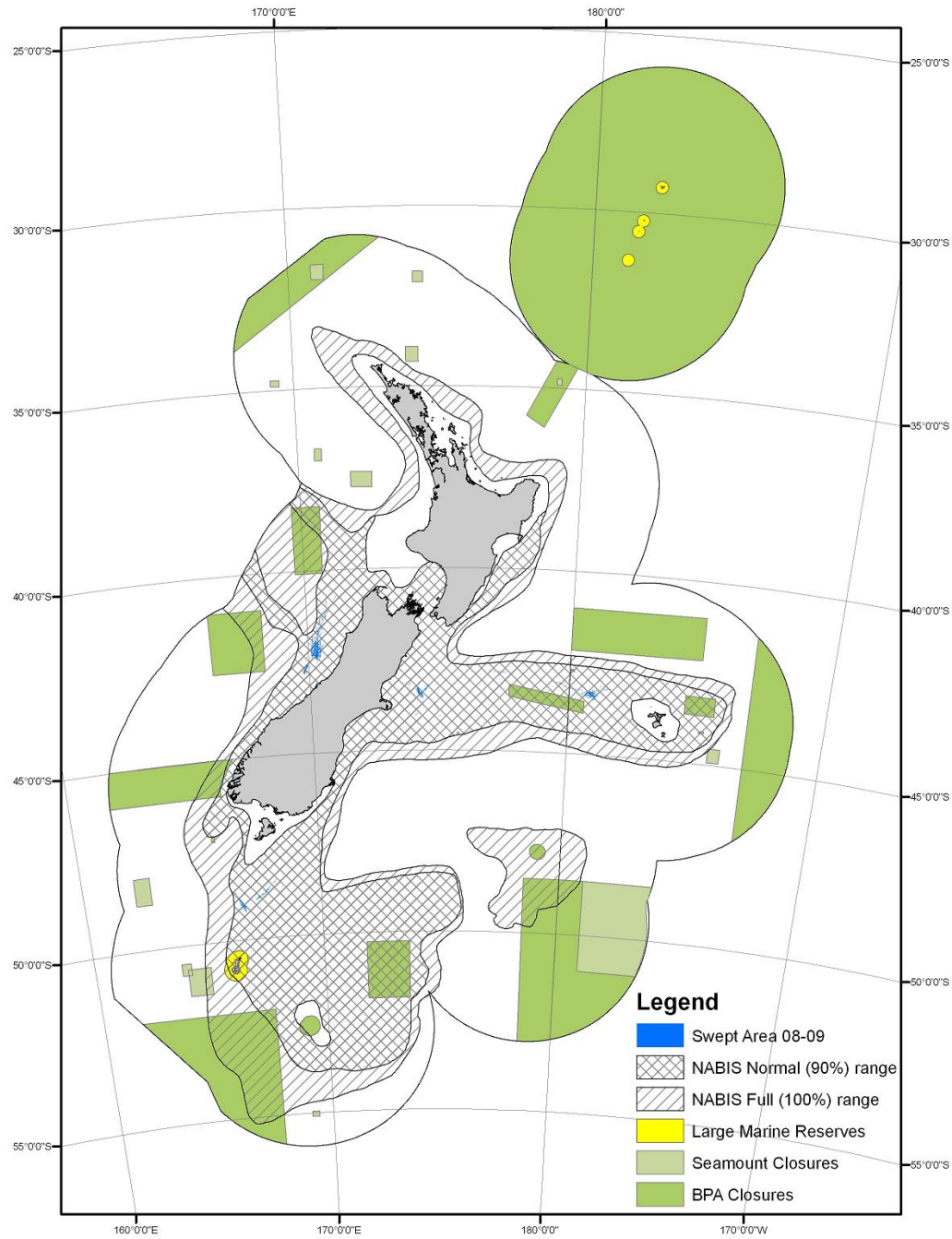
## Hake Bottom Trawl Grounds 1989-90 to 2008-09



HAK Bottom Trawl Grounds (1989–90 to 2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 321 149	100.00%	757 253	100.00%
Swept Area	5 382	0.13%	5 382	0.41%	5 362	0.71%
Area not trawled	4 115 749	99.87%	1 315 767	99.59%	751 891	99.29%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	149 879	11.34%	47 816	6.31%
Closed and/or not trawled	4 115 764	99.87%	1 315 782	99.59%	751 893	99.29%
No. of bottom trawls	13 447		13 435		13 431	

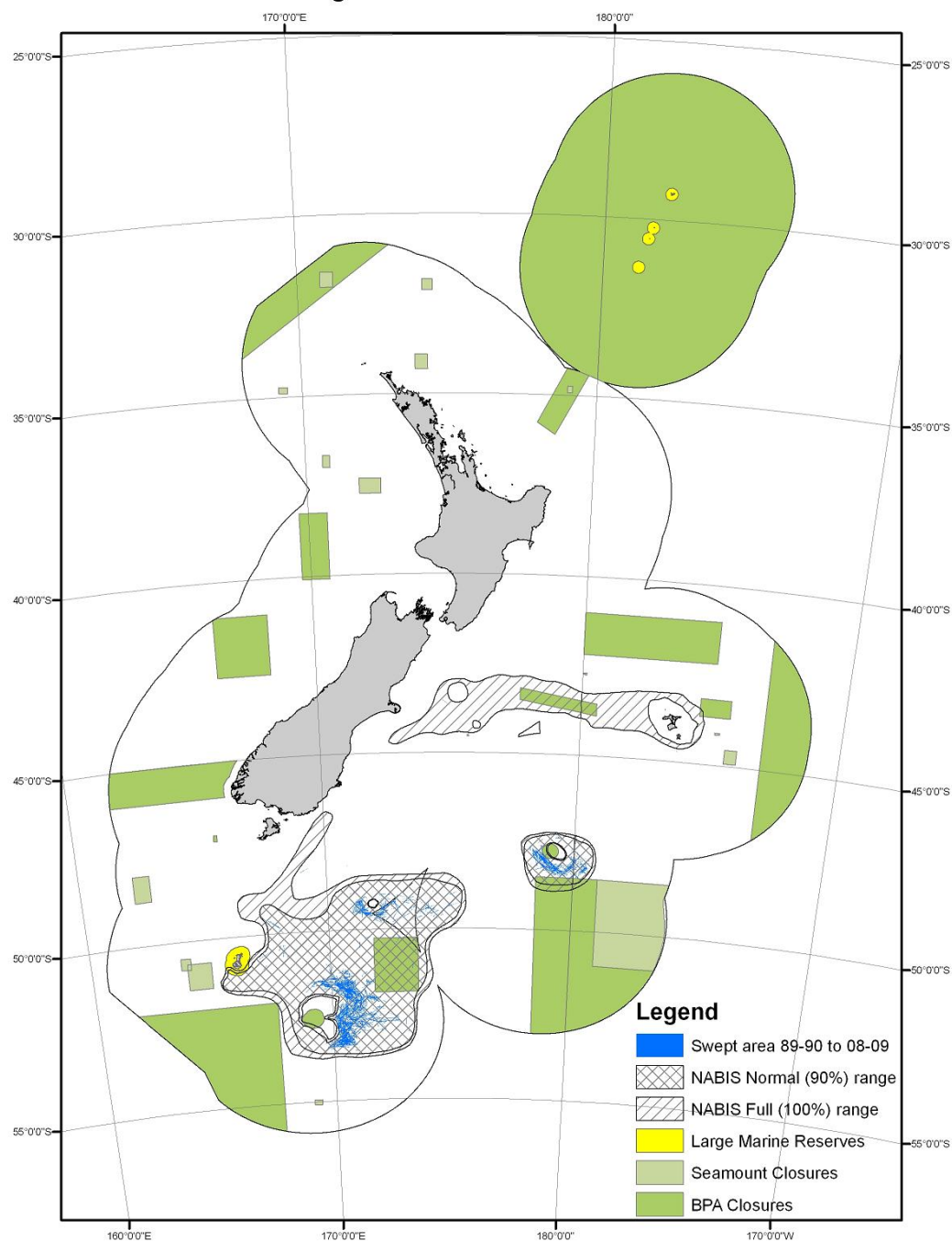


## Hake Bottom Trawl Grounds 2008-09



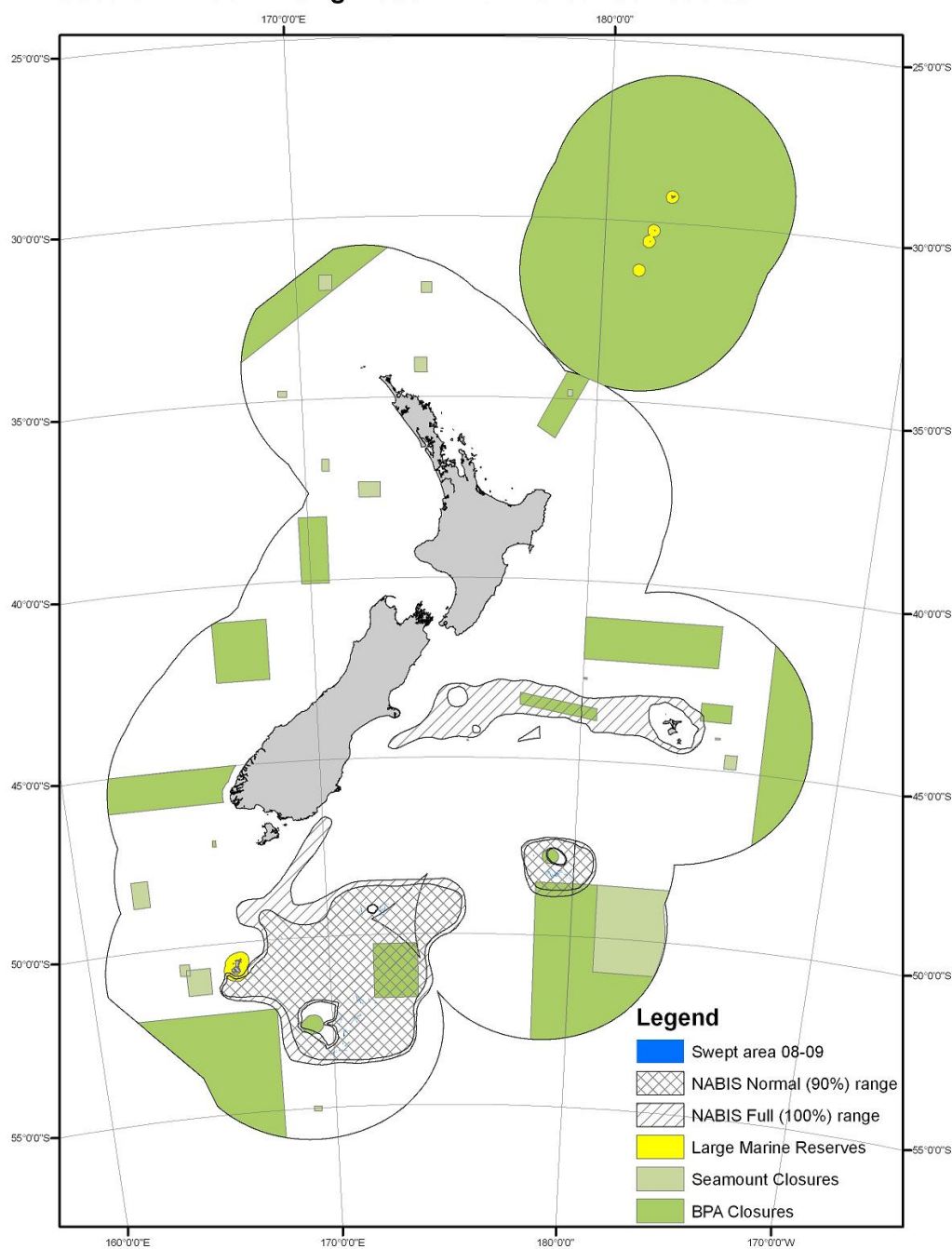
HAK Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 321 149	100.00%	757 253	100.00%
Swept Area	2 967	0.07%	2 967	0.22%	2 963	0.39%
Area not trawled	4 118 164	99.93%	1 318 182	99.78%	754 290	99.61%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	149 879	11.34%	47 816	6.31%
Closed and/or not trawled	4 118 166	99.93%	1 318 184	99.78%	754 292	99.61%
No. of bottom trawls	1 320		1 320		1 320	

## Southern Blue Whiting Bottom Trawl Grounds 1989-90 to 2008-09



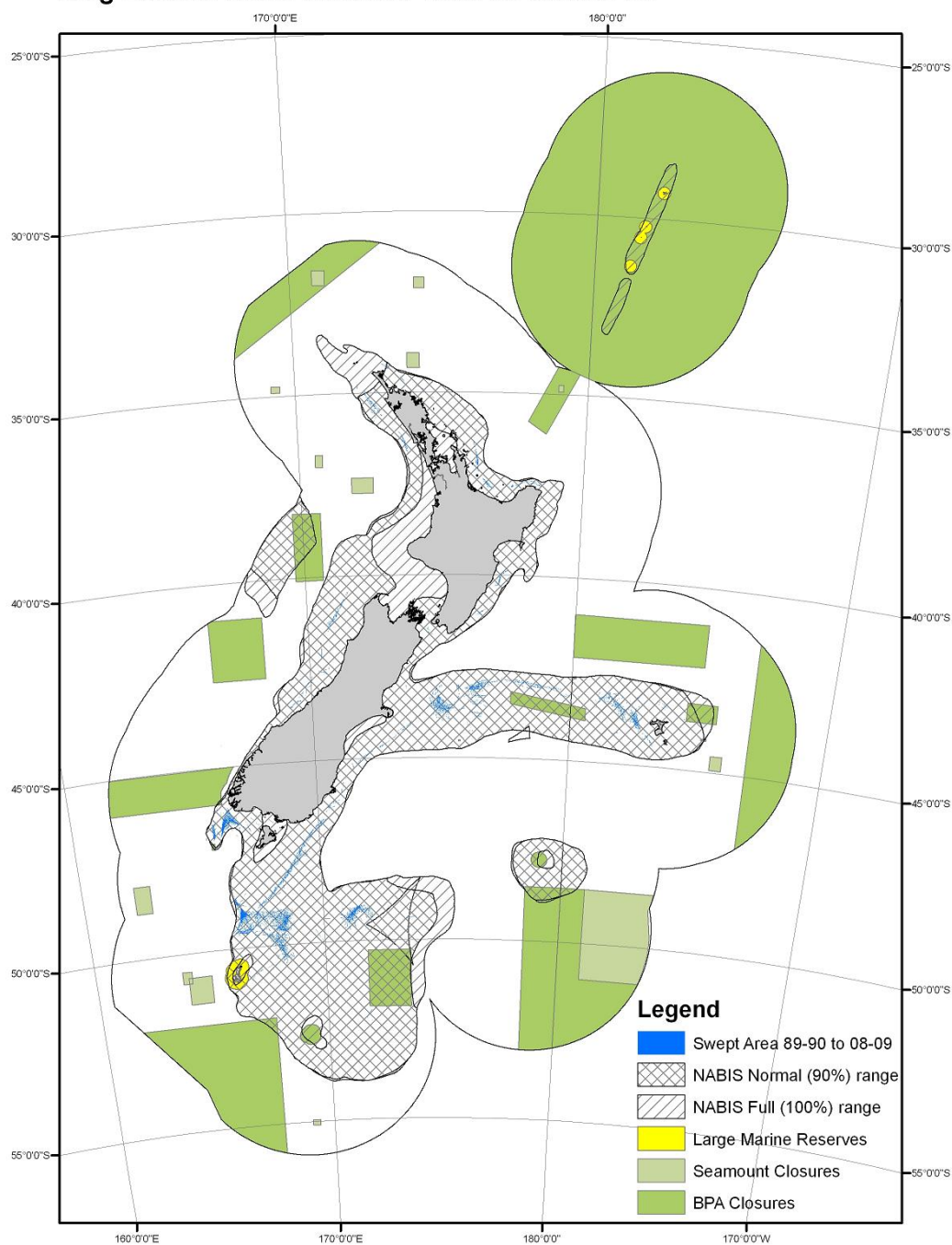
SBW Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	413 617	100.00%	252 049	100.00%
Swept Area	17 627	0.43%	17 572	4.25%	17 485	6.94%
Area not trawled	4 103 504	99.57%	396 045	95.75%	234 564	93.06%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	39 429	9.53%	26 403	10.48%
Closed and/or not trawled	4 103 589	99.57%	396 130	95.77%	234 647	93.10%
No. of bottom trawls	12 402		11 814		11 798	

## Southern Blue Whiting Bottom Trawl Grounds 2008-09



SBW Bottom Trawl Grounds (2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	413 617	100.00%	252 049	100.00%
Swept Area	1 014	0.02%	1 014	0.25%	1 014	0.40%
Area not trawled	4 120 117	99.98%	412 603	99.75%	251 035	99.60%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	39 429	9.53%	26 403	10.48%
Closed and/or not trawled	4 120 117	99.98%	412 603	99.75%	251 035	99.60%
No. of bottom trawls	574		574		574	

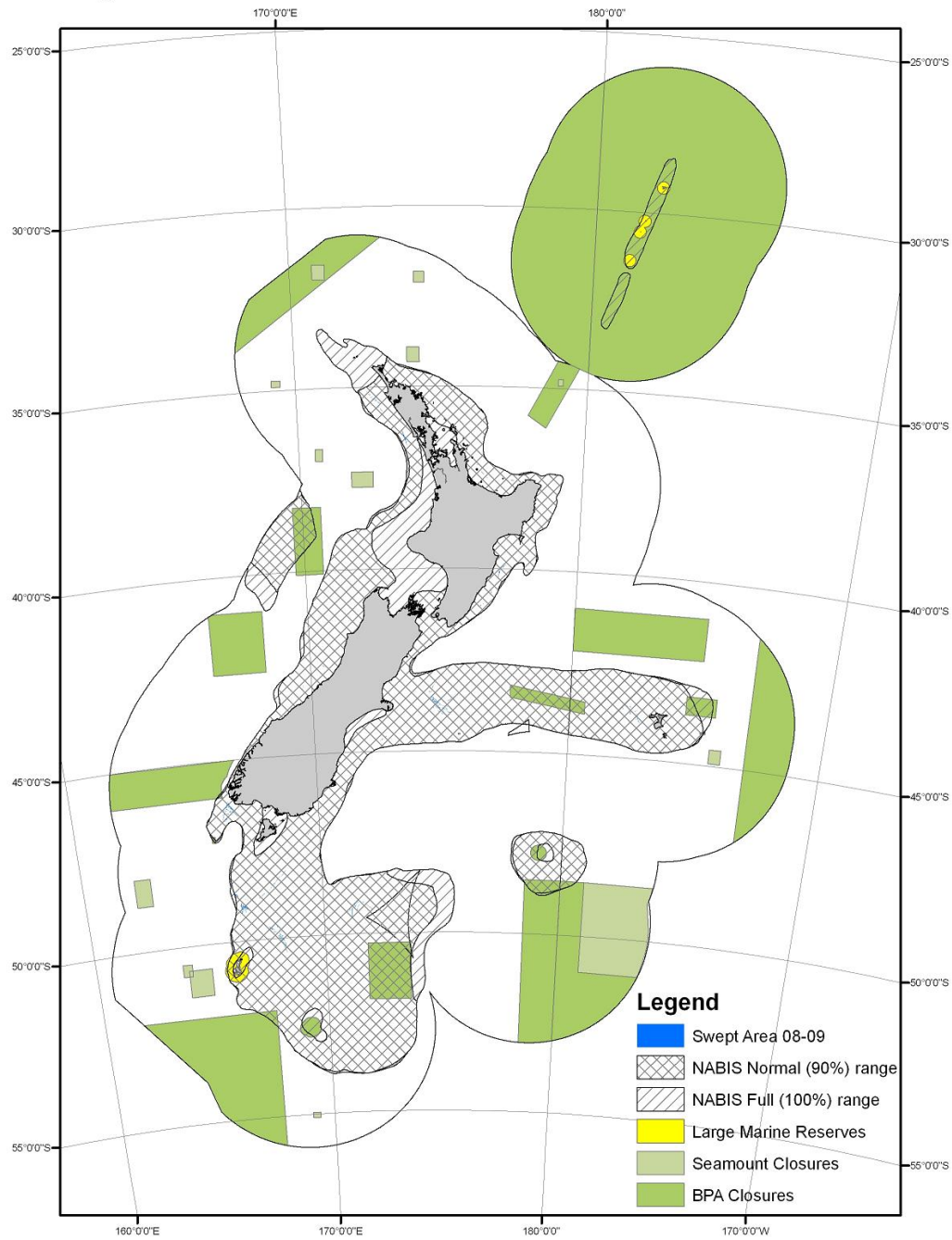
## Ling Bottom Trawl Grounds 1989-90 to 2008-09



LIN Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 017 357	100.00%	851 781	100.00%
Swept Area	12 627	0.31%	12 608	1.24%	12 553	1.47%
Area not trawled	4 108 504	99.69%	1 004 749	98.76%	839 228	98.53%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	80 608	7.92%	51 210	6.01%
Closed and/or not trawled	4 108 504	99.69%	1 004 749	98.76%	839 228	98.53%
No. of bottom trawls	11 976		11 814		11 798	

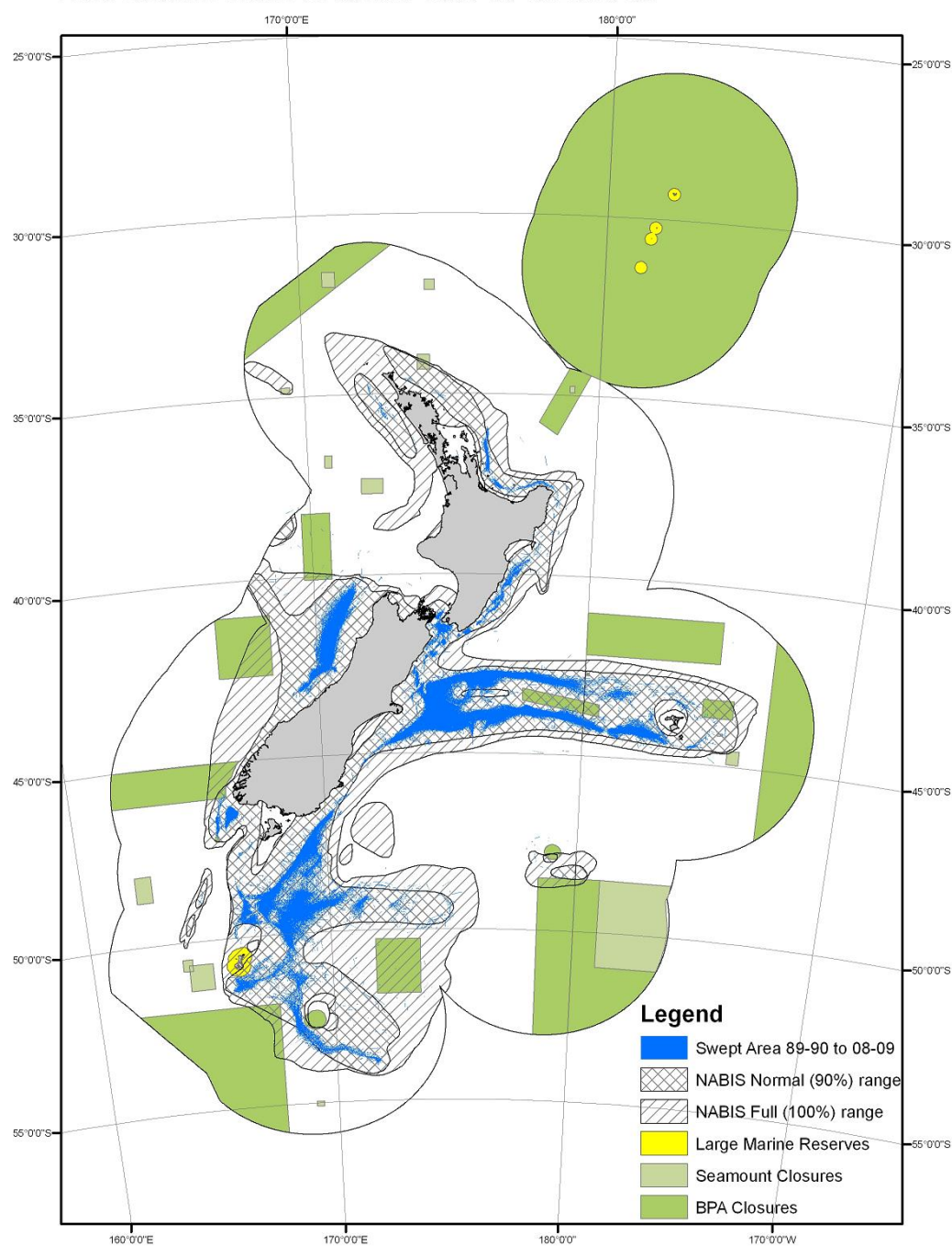


## Ling Bottom Trawl Grounds 2008-09



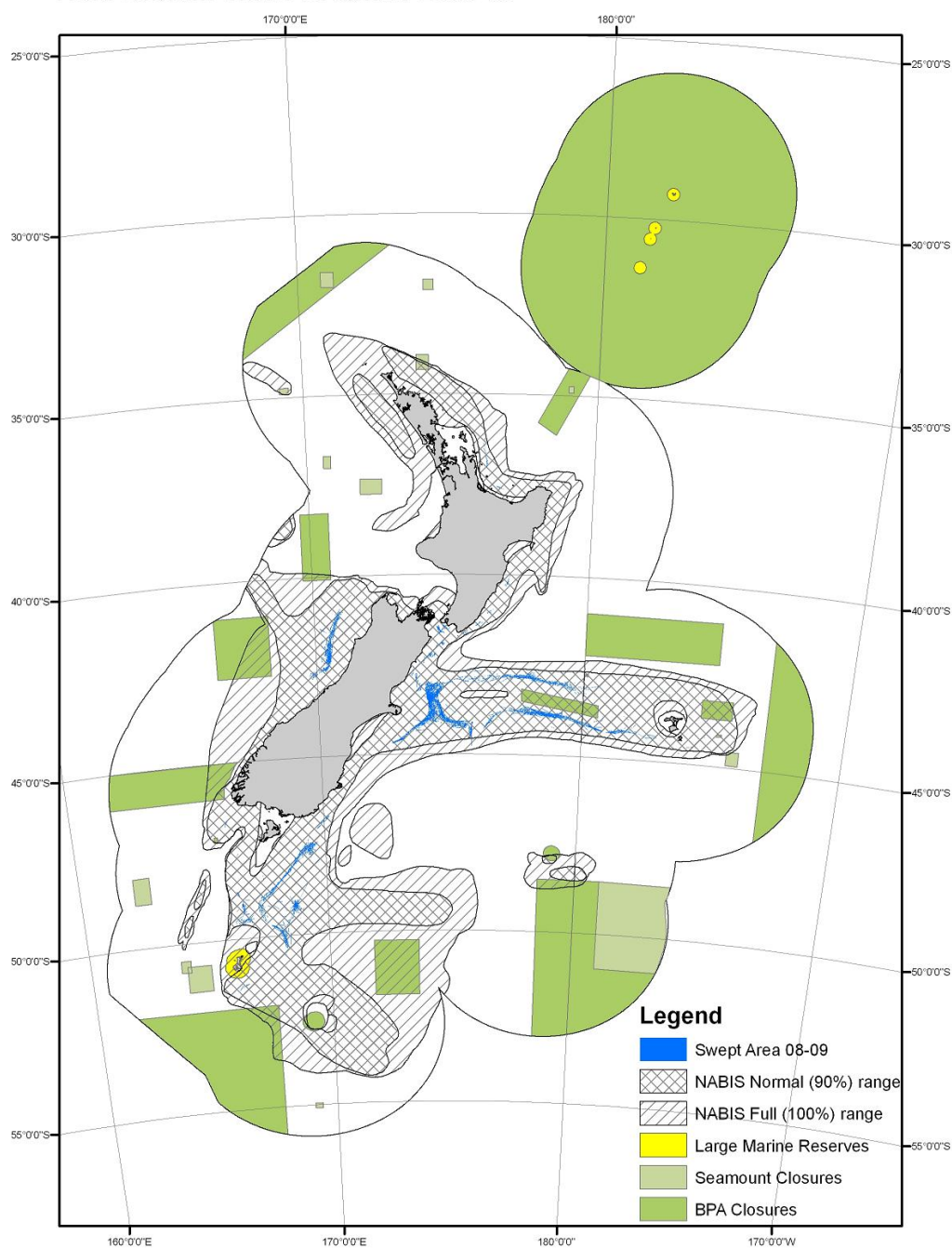
LIN Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 017 357	100.00%	851 781	100.00%
Swept Area	1 012	0.02%	1 012	0.10%	1 012	0.12%
Area not trawled	4 120 119	99.98%	1 016 345	99.90%	850 769	99.88%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	80 608	7.92%	51 210	6.01%
Closed and/or not trawled	4 120 119	99.98%	1 016 345	99.90%	850 769	99.88%
No. of bottom trawls	835		574		574	

## Hoki Bottom Trawl Grounds 1989-90 to 2008-09



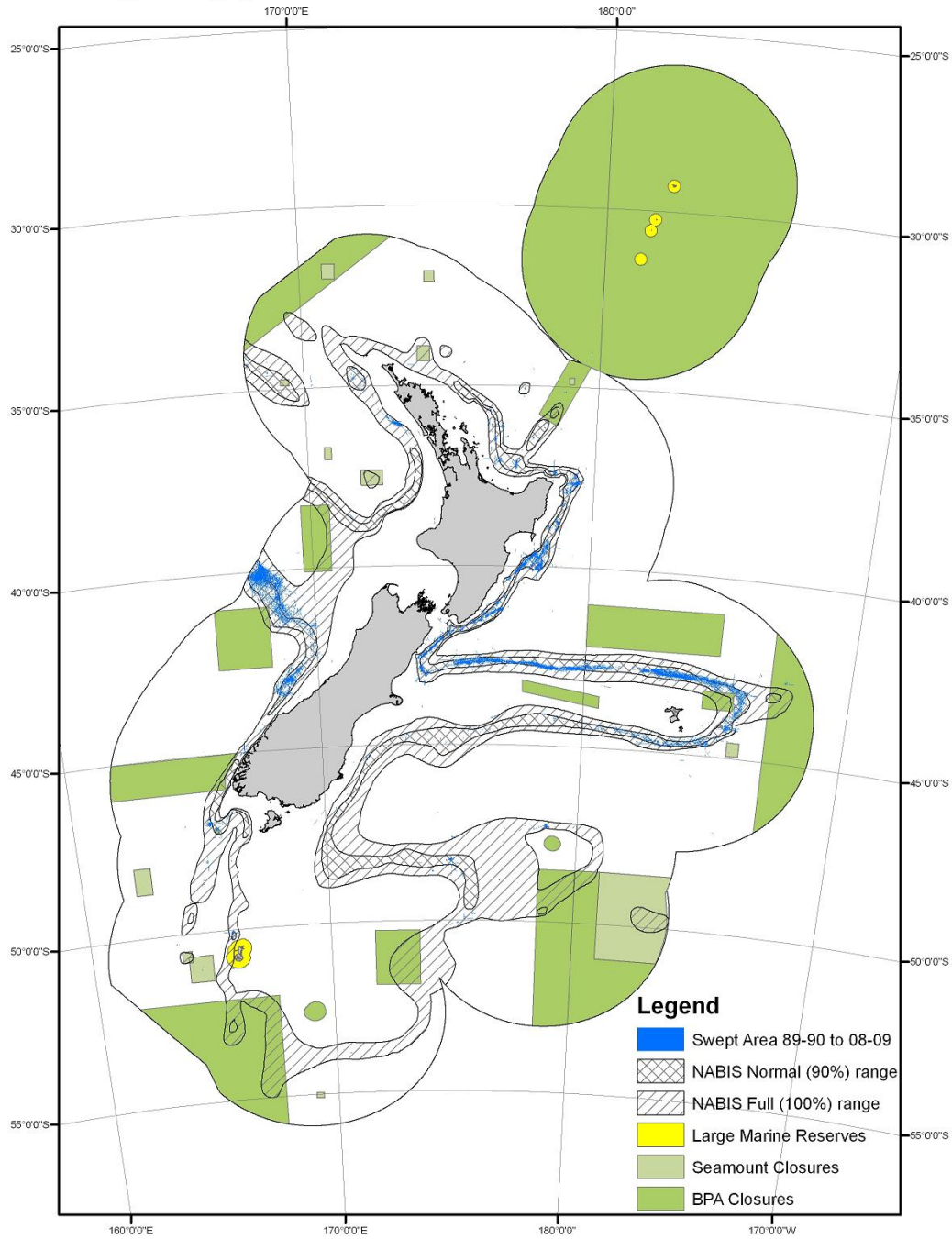
HOK Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 221 255	100.00%	692 695	100.00%
Swept Area	165 195	4.01%	164 758	13.49%	160 120	23.12%
Area not trawled	3 955 936	95.99%	1 056 497	86.51%	532 575	76.88%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	76 153	6.24%	19 990	2.89%
Closed and/or not trawled	3 956 343	96.00%	1 056 843	86.54%	532 843	76.92%
No. of bottom trawls	318 944		318 839		317 914	

## Hoki Bottom Trawl Grounds 2008-09



HOK Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	1 221 255	100.00%	692 695	100.00%
Swept Area	18 137	0.44%	18 137	1.49%	18 115	2.62%
Area not trawled	4 102 994	99.56%	1 203 118	98.51%	674 580	97.38%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	76 153	6.24%	19 990	2.89%
Closed and/or not trawled	4 102 994	99.56%	1 203 118	98.51%	674 580	97.38%
No. of bottom trawls	6 462		6 462		6 458	

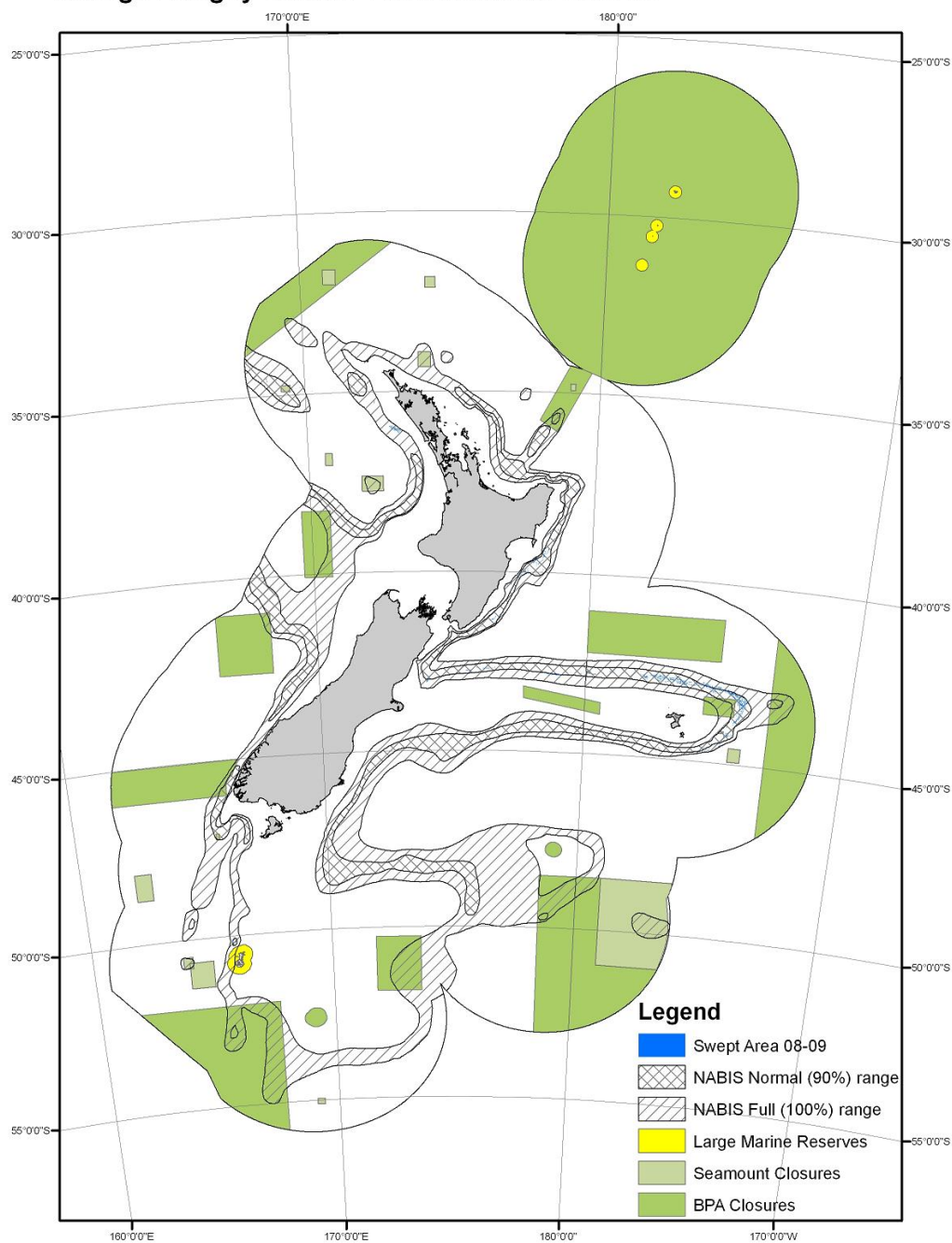
## Orange Roughy Bottom Trawl Grounds 1989-90 to 2008-09



ORH Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	741 560	100.00%	178 880	100.00%
Swept Area	33 651	0.82%	32 296	4.36%	22 833	12.76%
Area not trawled	4 087 480	99.18%	709 264	95.64%	156 047	87.24%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	81 723	11.02%	3 988	2.23%
Closed and/or not trawled	4 087 712	99.19%	709 397	95.66%	156 146	87.29%
No. of bottom trawls	99 008		95 904		74 100	

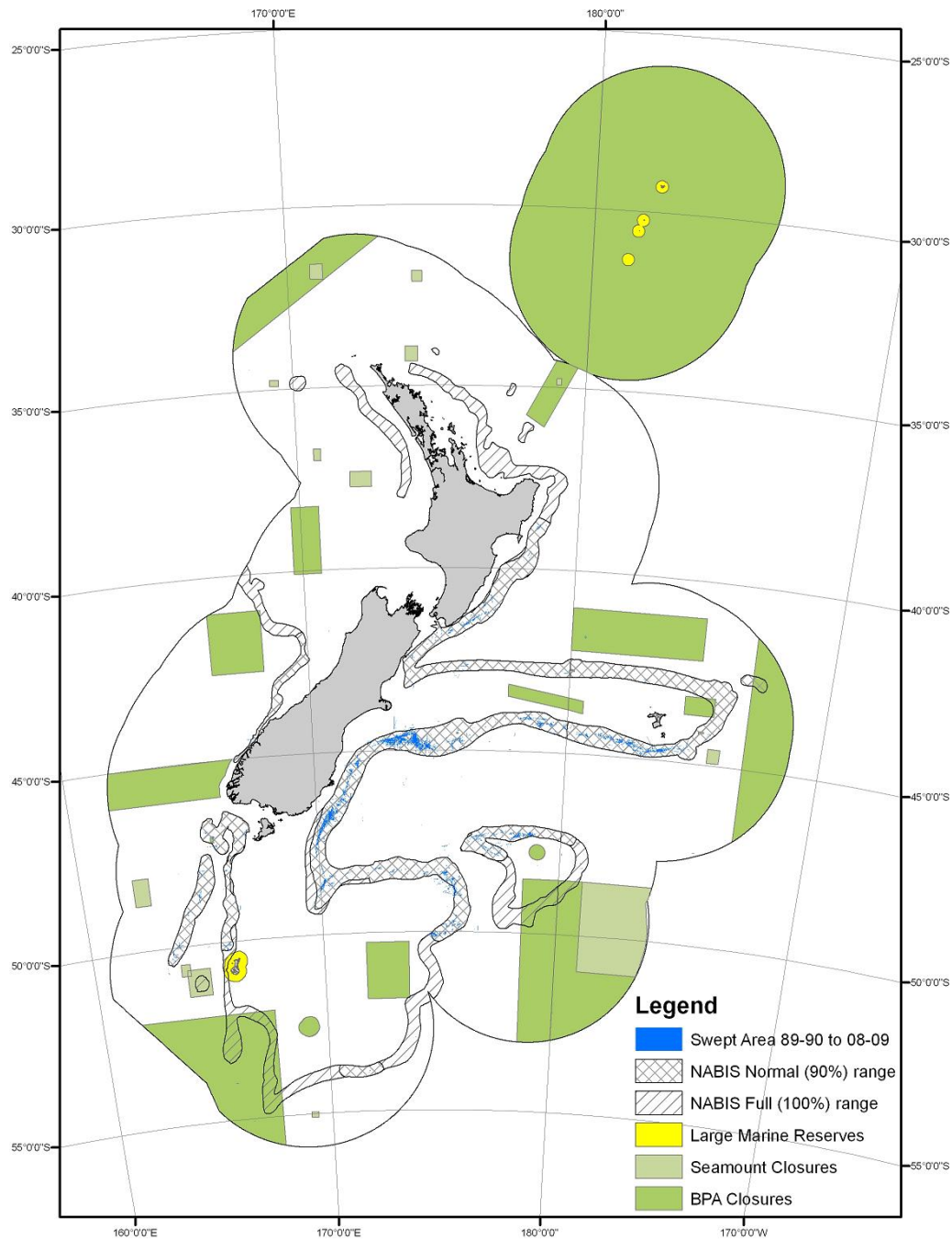


## Orange Roughy Bottom Trawl Grounds 2008-09



ORH Bottom Trawl Grounds (2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	741 560	100.00%	178 880	100.00%
Swept Area	2 343	0.06%	2 296	0.31%	1 756	0.98%
Area not trawled	4 118 788	99.94%	739 264	99.69%	177 124	99.02%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	81 723	11.02%	3 988	2.23%
Closed and/or not trawled	4 118 790	99.94%	739 266	99.69%	177 124	99.02%
No. of bottom trawls	3 084		3 049		2 203	

## Oreo Bottom Trawl Grounds 1989-90 to 2008-09



OEO Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	411 886	100.00%	265 623	100.00%
Swept Area	12 675	0.31%	11 900	2.89%	11 761	4.43%
Area not trawled	4 108 456	99.69%	399 986	97.11%	253 862	95.57%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	30 737	7.46%	2 489	0.94%
Closed and/or not trawled	4 108 499	99.69%	400 009	97.12%	253 877	95.58%
No. of bottom trawls	42 417		40 928		40 827	

## Oreo Bottom Trawl Grounds 2008-09



OEO Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	411 886	100.00%	265 623	100.00%
Swept Area	680	0.02%	612	0.15%	609	0.23%
Area not trawled	4 120 451	99.98%	411 274	99.85%	265 014	99.77%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	30 737	7.46%	2 489	0.94%
Closed and/or not trawled	4 120 451	99.98%	411 274	99.85%	265 014	99.77%
No. of bottom trawls	1 758		1 546		1 543	

## Jack Mackerel Bottom Trawl Grounds 1989-90 to 2008-09



JMA Bottom Trawl Grounds (1989-90 to 2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	452 700	100.00%	356 194	100.00%
Swept Area	41 092	1.00%	40 688	8.99%	40 116	11.26%
Area not trawled	4 080 039	99.00%	412 012	91.01%	316 078	88.74%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	26 894	5.94%	8 768	2.46%
Closed and/or not trawled	4 080 045	99.00%	412 016	91.01%	316 081	88.74%
No. of bottom trawls	41 249		41 172		41 006	

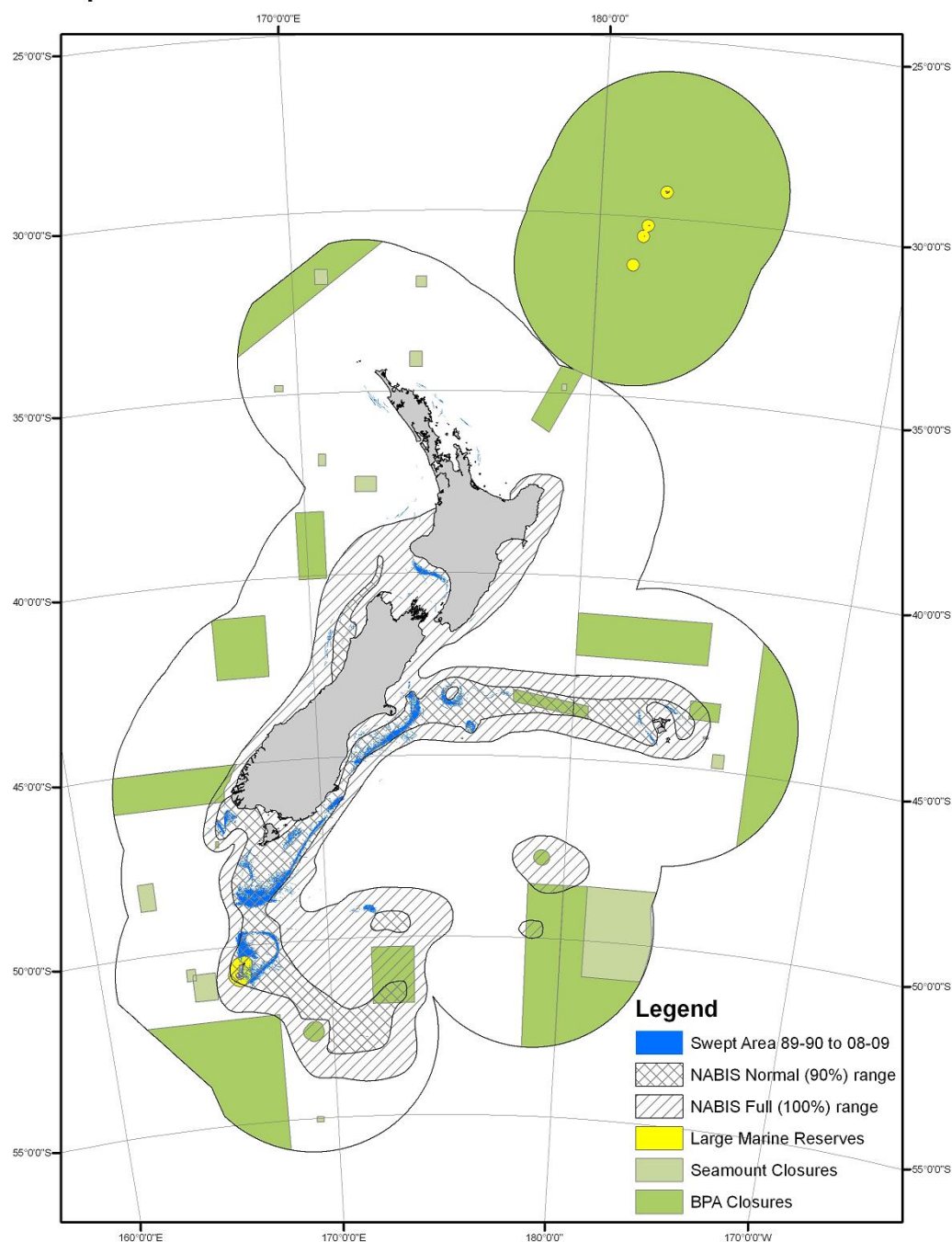


## Jack Mackerel Bottom Trawl Grounds 2008-09



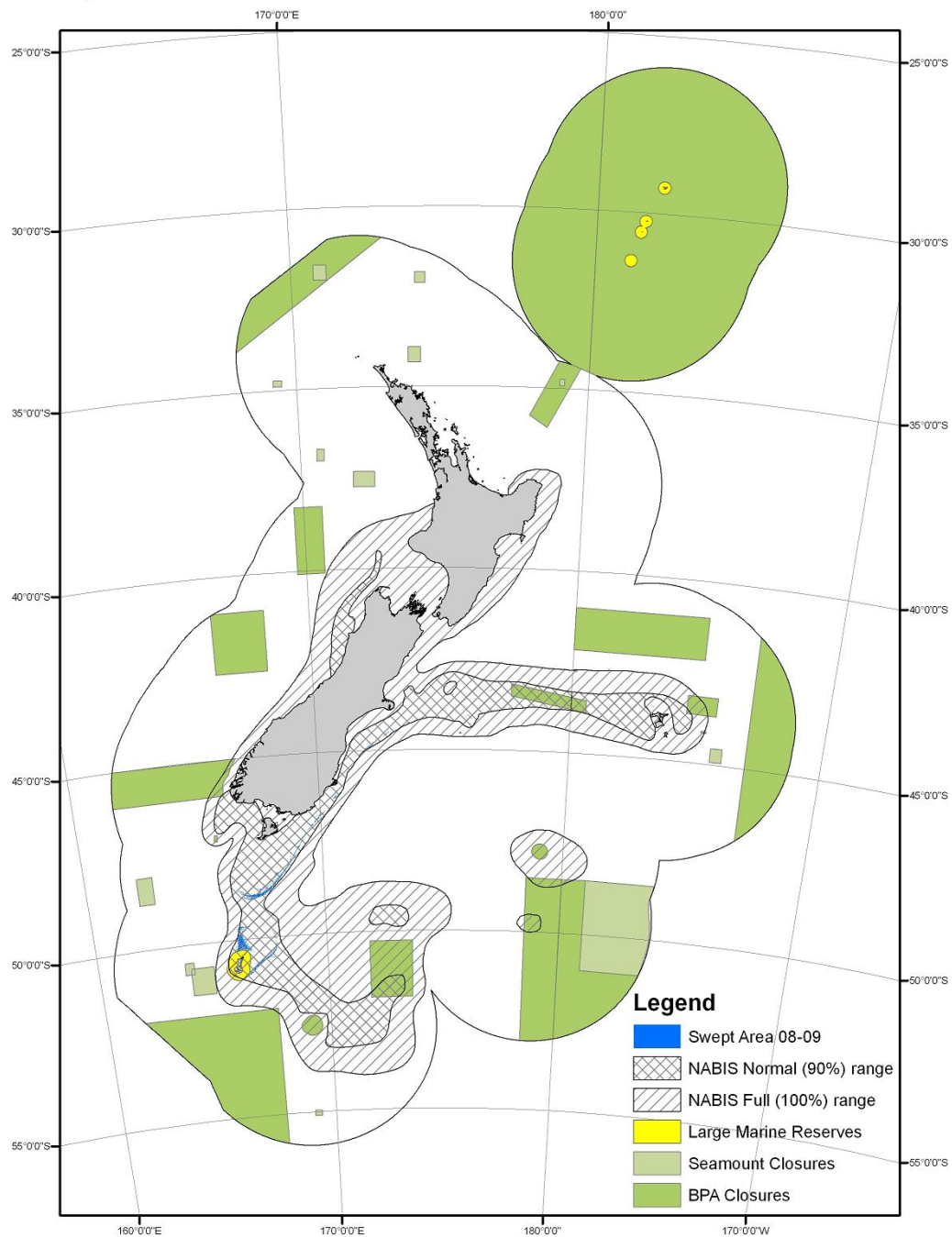
JMA Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	452 700	100.00%	395 194	100.00%
Swept Area	4 199	0.10%	4 196	0.93%	4 162	1.17%
Area not trawled	4 116 932	99.90%	448 504	99.07%	391 032	98.83%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	26 894	5.94%	8 768	2.46%
Closed and/or not trawled	4 116 932	99.90%	448 505	99.07%	352 031	98.83%
No. of bottom trawls	1 468		1 467		1 453	

## Squid Bottom Trawl Grounds 1989-90 to 2008-09



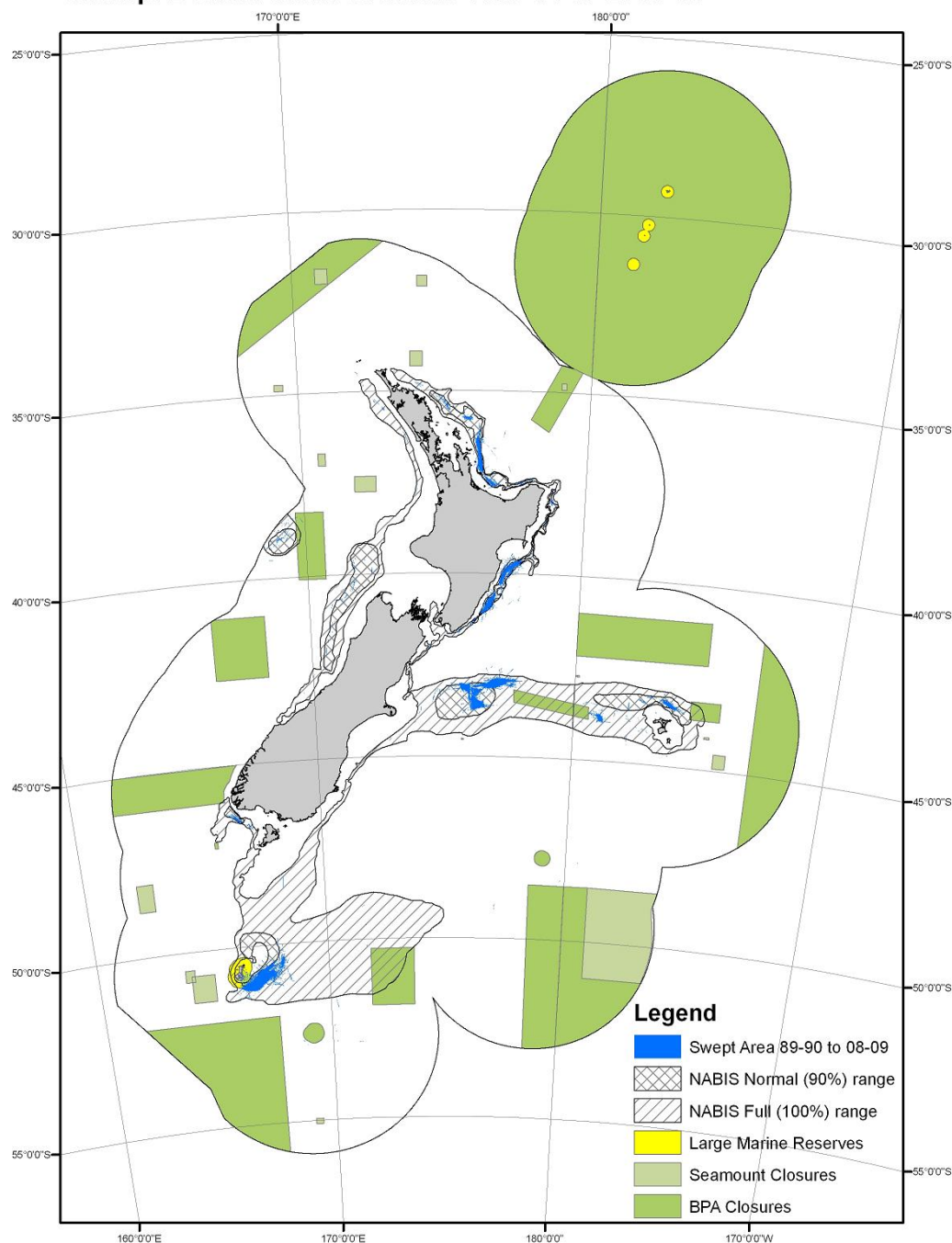
SQU Bottom Trawl Grounds (1989–90 to 2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	847 369	100.00%	255 497	100.00%
Swept Area	32 931	0.80%	32 449	3.83%	27 566	10.79%
Area not trawled	4 088 200	99.20%	814 920	96.17%	227 931	89.21%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	52 010	6.14%	18 412	7.21%
Closed and/or not trawled	4 088 573	99.21%	815 291	96.21%	228 302	89.36%
No. of bottom trawls	144 343		144 211		140 976	

## Squid Bottom Trawl Grounds 2008-09



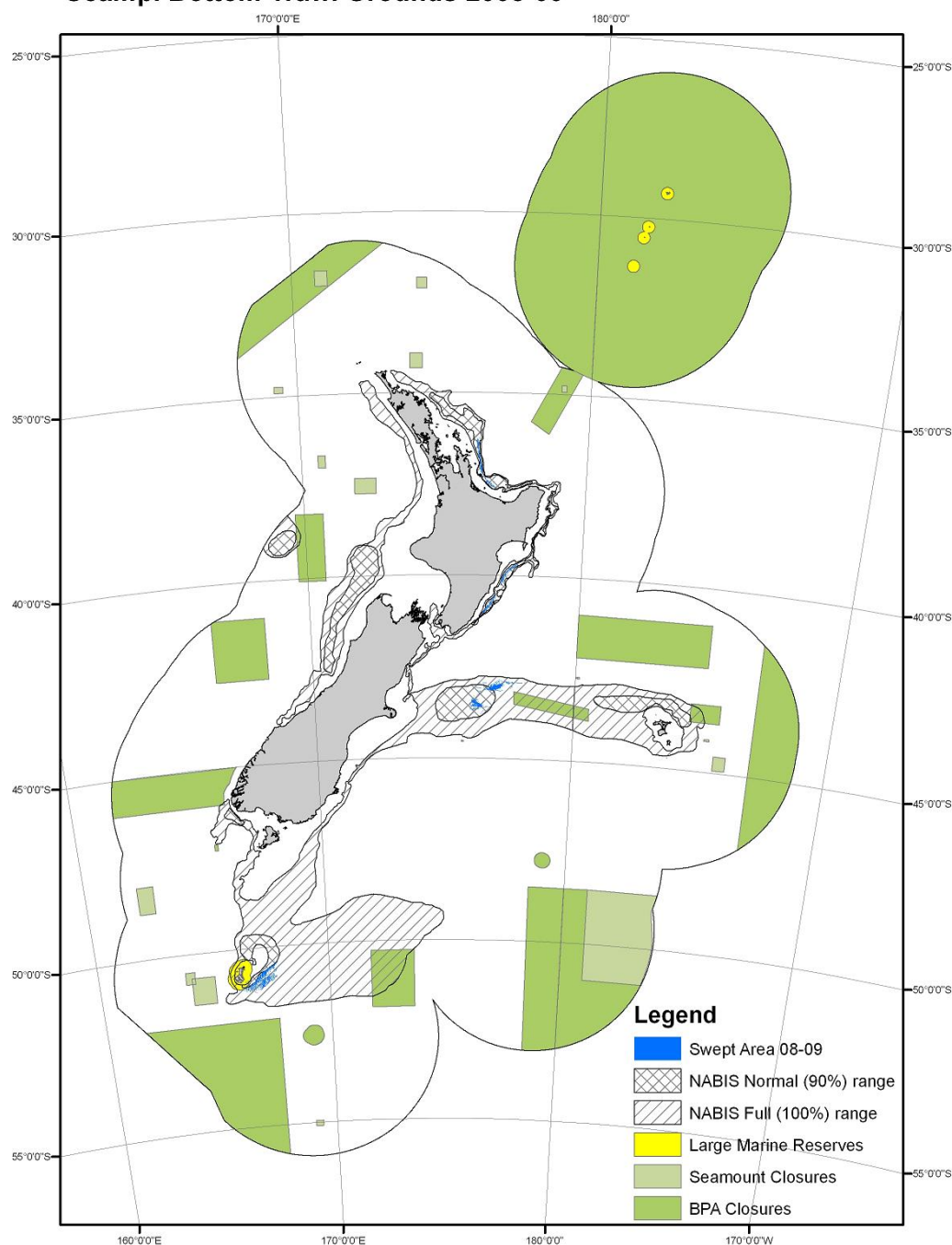
SQU Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	847 369	100.00%	255 497	100.00%
Swept Area	3 640	0.09%	3 640	0.43%	3 543	1.39%
Area not trawled	4 117 491	99.91%	843 729	99.57%	251 954	98.61%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	52 010	6.14%	18 412	7.21%
Closed and/or not trawled	4 117 498	99.91%	843 736	99.57%	251 961	98.62%
No. of bottom trawls	3 312		3 312		3 281	

## Scampi Bottom Trawl Grounds 1989-90 to 2008-09



SCI Bottom Trawl Grounds (1989–90 to 2008–09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	417 875	100.00%	74 888	100.00%
Swept Area	21 743	0.53%	20 260	4.85%	10 483	14.00%
Area not trawled	4 099 388	99.47%	397 615	95.15%	64 405	86.00%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	24 349	5.83%	311	0.42%
Closed and/or not trawled	4 099 804	99.48%	397 789	95.19%	64 509	86.14%
No. of bottom trawls	85 940		85 812		57 615	

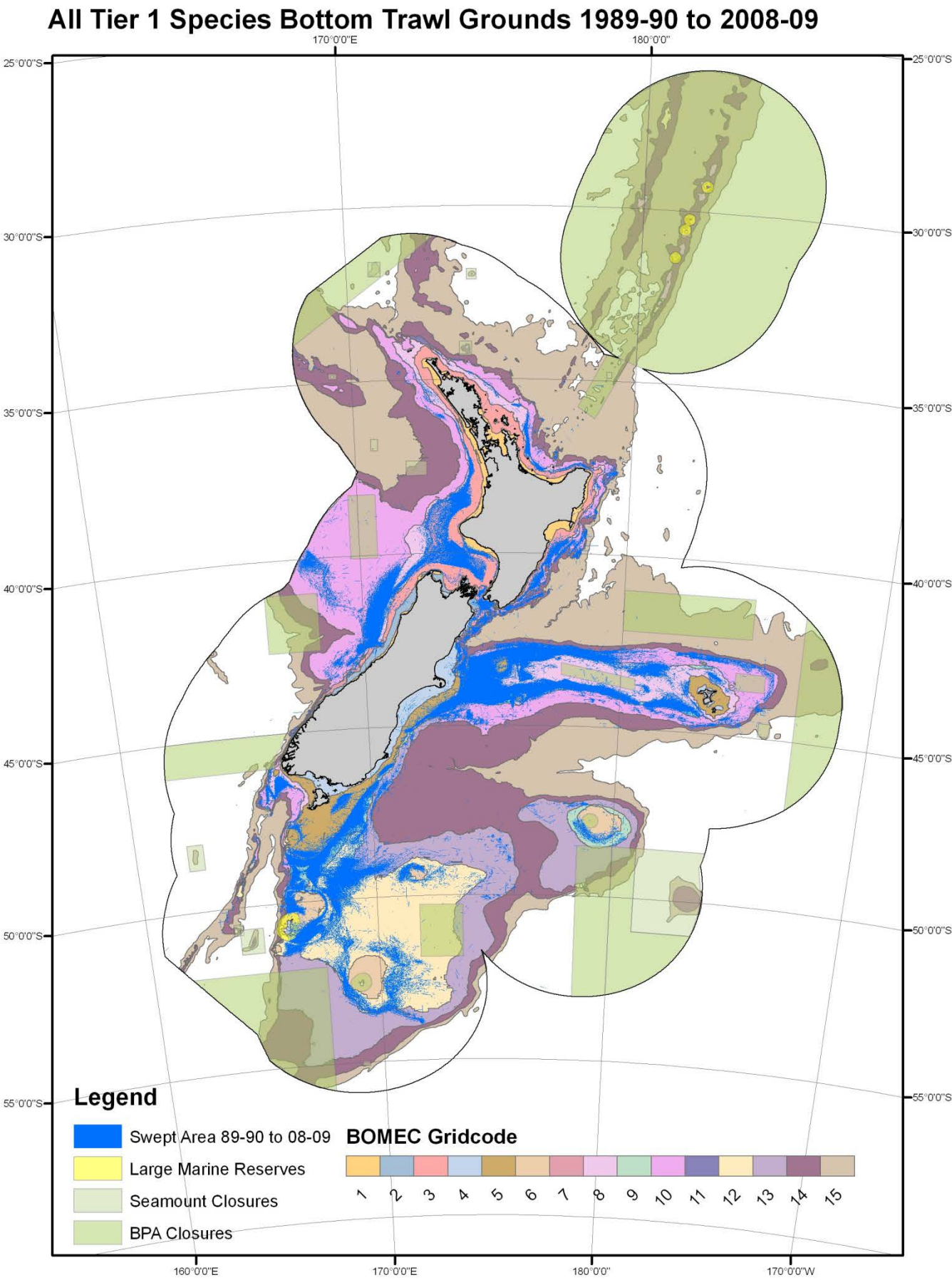
## Scampi Bottom Trawl Grounds 2008-09



SCI Bottom Trawl Grounds (2008-09)	Area in EEZ & TS (km <sup>2</sup> )	Area in EEZ & TS (%)	Area in Combined NABIS Full Range (km <sup>2</sup> )	Area in Combined NABIS Full Range (%)	Area in Combined NABIS Normal Range (km <sup>2</sup> )	Area in Combined NABIS Normal Range (%)
EEZ & TS	4 121 131	100.00%	417 875	100.00%	74 888	100.00%
Swept Area	4 212	0.10%	4 173	1.00%	1 995	2.66%
Area not trawled	4 116 919	99.90%	413 702	99.00%	72 893	97.34%
Closed area (BPA, Seamount, Large Marine Reserve)	1 218 023	29.56%	24 349	5.83%	311	0.42%
Closed and/or not trawled	4 116 949	99.90%	413 716	99.00%	72 899	97.34%
No. of bottom trawls	3 876		3 875		2 410	

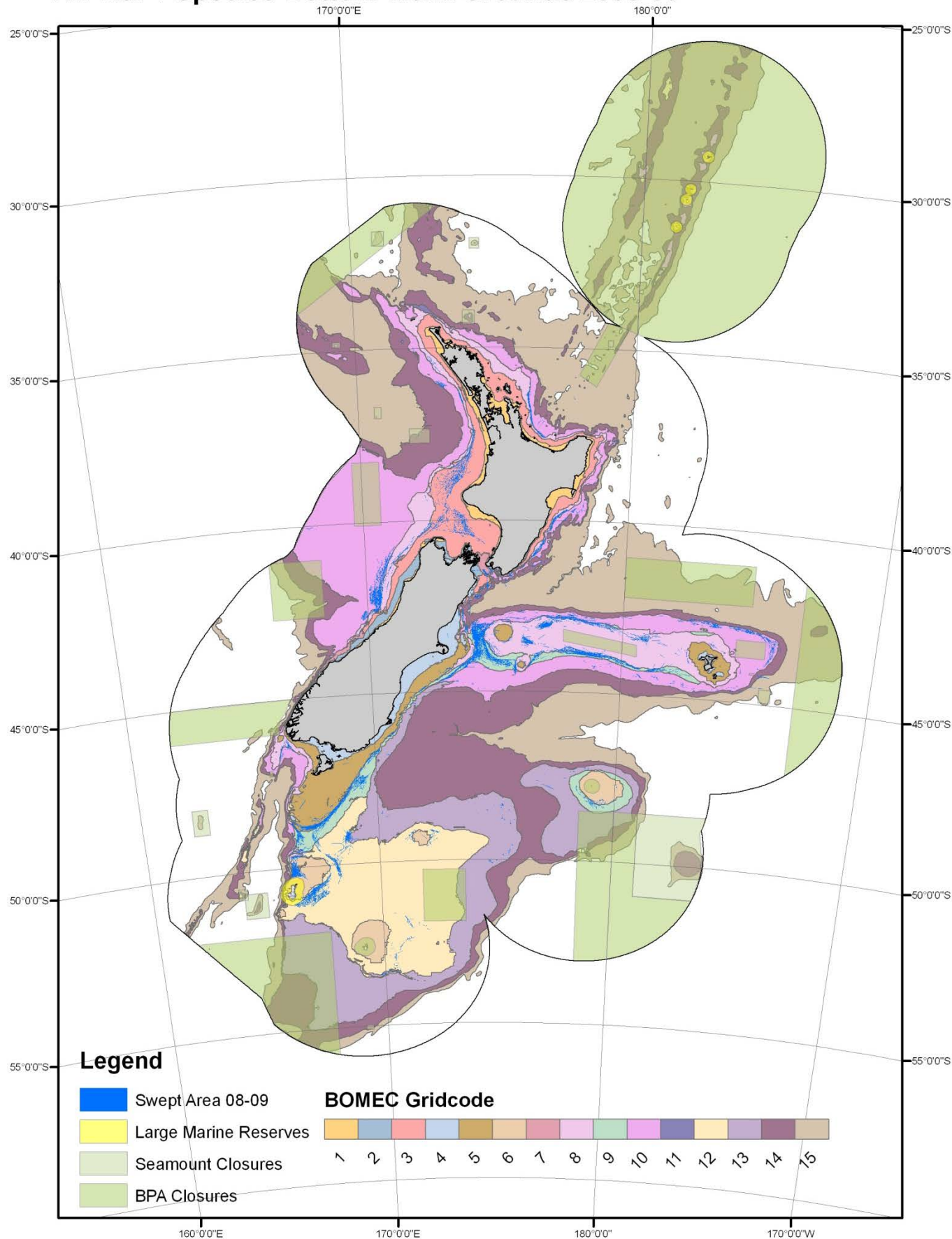


APPENDIX 2 TIER 1 SPECIES BOMECS FIGURES AND STATISTICS



BOMECS Gridcode	Area (km <sup>2</sup> )	Swept area 1989-90 to 2008-09 (km <sup>2</sup> )	Area not trawled (km <sup>2</sup> )	Area not trawled (%)	Closed area (BPA, Seamount, Large Marine Reserve) (km <sup>2</sup> )	Closed area (BPA, Seamount, Large Marine Reserve) (%)	Area closed and/or not trawled (km <sup>2</sup> )	Area closed and/or not trawled (%)
1	27 557	521	27 036	98.11%	0	0.00%	27 036	98.11%
2	12 420	458	11 962	96.31%	0	0.00%	11 962	96.31%
3	89 710	26 735	62 975	70.20%	0	0.00%	62 975	70.20%
4	27 268	1 601	25 667	94.13%	0	0.00%	25 667	94.13%
5	60 990	17 011	43 979	72.11%	0	0.00%	43 979	72.11%
6	38 609	6 017	32 592	84.42%	7 601	19.69%	33 098	85.73%
7	6 342	2 087	4 255	67.10%	18	0.28%	4 255	67.10%
8	138 551	56 161	82 390	59.47%	9 162	6.61%	82 593	59.61%
9	52 224	37 441	14 783	28.31%	296	0.57%	14 786	28.31%
10	311 361	64 995	246 366	79.13%	34 172	10.98%	246 637	79.21%
11	1 289	5	1 284	99.62%	0	0.00%	1 284	99.62%
12	198 577	53 144	145 433	73.24%	23 043	11.60%	145 688	73.37%
13	233 825	16 864	216 961	92.79%	50 032	21.40%	217 028	92.82%
14	493 034	8 405	484 629	98.30%	103 922	21.08%	484 659	98.30%
15	935 315	1 556	933 759	99.83%	336 693	36.00%	933 820	99.84%
Total	2 627 073	293 001	2 334 072	88.85%	564 940	21.50%	2 335 466	88.90%

All Tier 1 Species Bottom Trawl Grounds 2008-09



BOMECS Gridcode	Area (km <sup>2</sup> )	Swept area 2008–09 (km <sup>2</sup> )	Area not trawled (km <sup>2</sup> )	Area not trawled (%)	Closed area (BPA, Seamount, Large Marine Reserve) (km <sup>2</sup> )	Closed area (BPA, Seamount, Large Marine Reserve) (%)	Area closed and/or not trawled (km <sup>2</sup> )	Area closed and/or not trawled (%)
1	27 557	0	27 557	100.00%	0	0.00%	27 557	100.00%
2	12 420	8	12 412	99.93%	0	0.00%	12 412	99.93%
3	89 710	3 470	86 240	96.13%	0	0.00%	86 240	96.13%
4	27 268	23	27 245	99.91%	0	0.00%	27 245	99.91%
5	60 990	1 644	59 345	97.30%	0	0.00%	59 345	97.30%
6	38 609	1 292	37 317	96.65%	7 601	19.69%	37 334	96.70%
7	6 342	239	6 103	96.24%	18	0.28%	6 103	96.24%
8	138 551	7 577	130 974	94.53%	9 162	6.61%	130 977	94.53%
9	52 224	9 629	42 595	81.56%	296	0.57%	42 595	81.56%
10	311 361	7 494	303 867	97.59%	34 172	10.98%	303 867	97.59%
11	1 289	0	1 289	100.00%	0	0.00%	1 289	100.00%
12	198 577	4 282	194 295	97.84%	23 043	11.60%	194 313	97.85%
13	233 825	630	233 195	99.73%	50 032	21.40%	233 195	99.73%
14	493 034	460	492 575	99.91%	103 922	21.08%	492 576	99.91%
15	935 315	78	935 237	99.99%	336 693	36.00%	935 238	99.99%
Total	2 627 073	36 826	2 590 246	98.60%	564 940	21.50%	2 590 287	98.60%